City of Charleston Resilience

CHARLESTON CITY COUNCIL WORKSHOP

July 2017

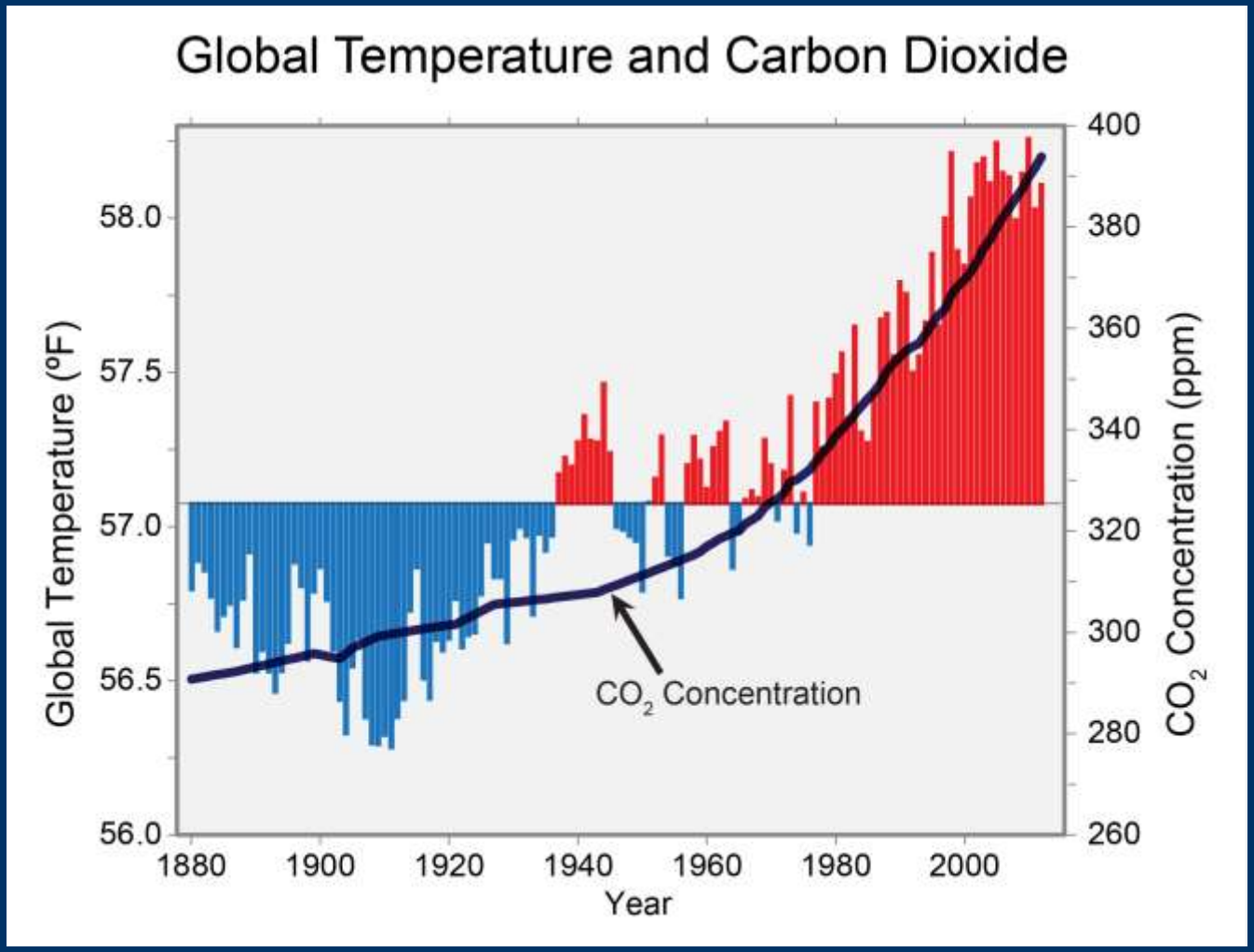
CITY OF CHARLESTON RESILIENCE AGENDA

- Introduction
  - Opportunity to shape the future
- Science and Community
  - Doug Marcy - NOAA Office for Coastal Management
    - Charleston observations and predictions
  - Cathryn Zommer – Enough Pie, Executive Director
- Resilience Workgroup
  - Mark Wilbert – Process, Categories, Results
  - Tracy McKee – Use of Data – Resilience Storyboard
  - Mark Wilbert & Katie McKain- Vulnerability Analysis
- Implementation
  - Laura Cabiness – Infrastructure (Past, Present & Future)
  - Jacob Lindsey- Land Use Planning & City's Plans
  - Chiefs Tippett and Broughton – adapting now and for the future

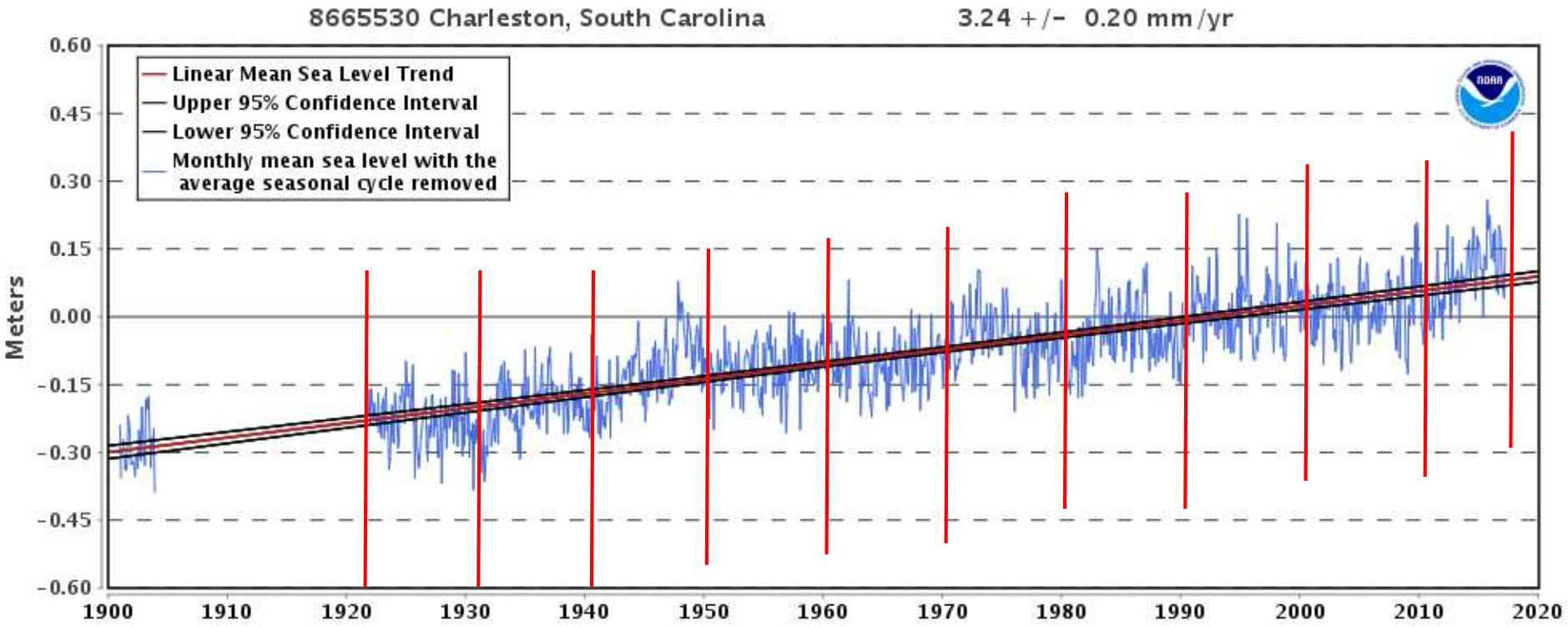
Understanding and Using Local SLR Scenarios

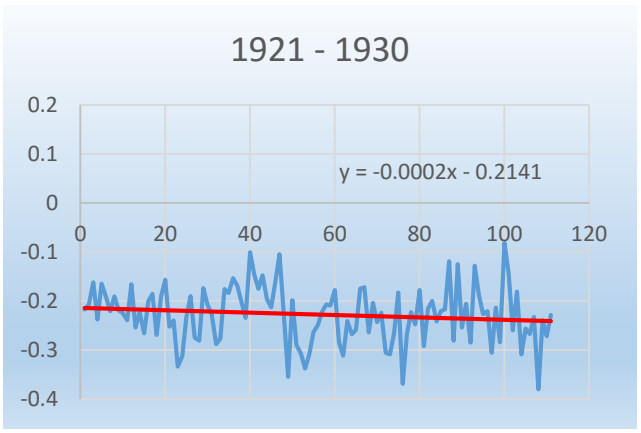
Doug Marcy
NOAA Office for Coastal Management

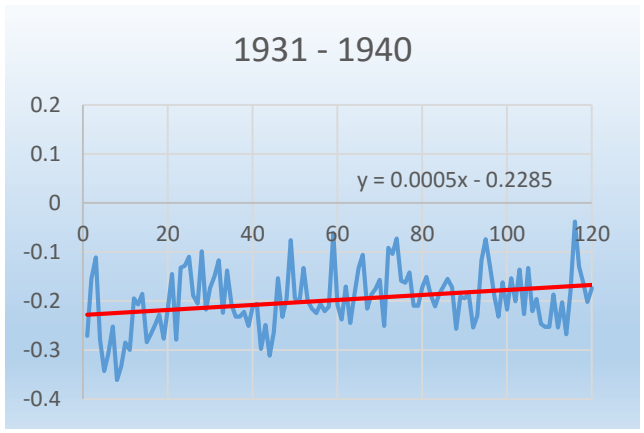
Past Global Temperature / CO^2



1921 – 2017 (10 year intervals)




1921 - 1930
y = -0.0002x - 0.2141
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
0
20
40
60
80
100
120


1931 - 1940
y = 0.0005x - 0.2285
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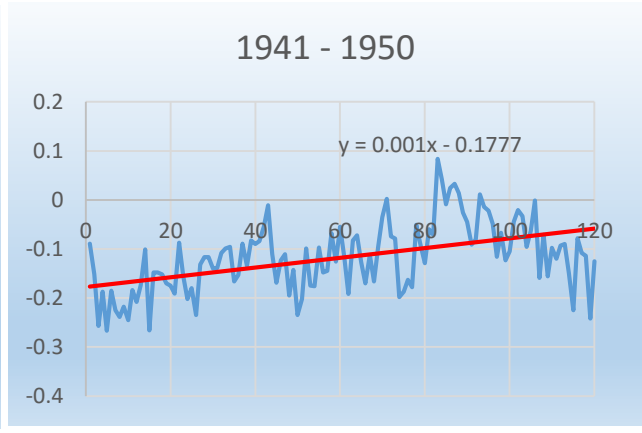
0
-0.1
-0.2
-0.3
-0.4
0
20
40
60
80
100
120


1941 - 1950
y = 0.001x - 0.1777
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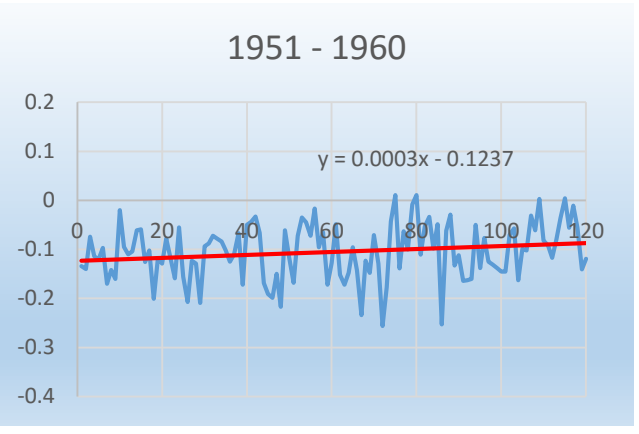
0.1
0
-0.1
-0.2
-0.3
-0.4
0
20
40
60
80
100
120


1951 - 1960
y = 0.0003x - 0.1237
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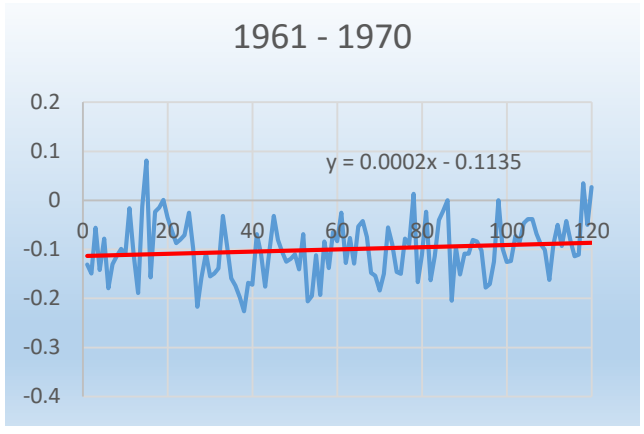
0
-0.1
-0.2
-0.3
-0.4
0
20
40
60
80
100
120


1961 - 1970
y = 0.0002x - 0.1135
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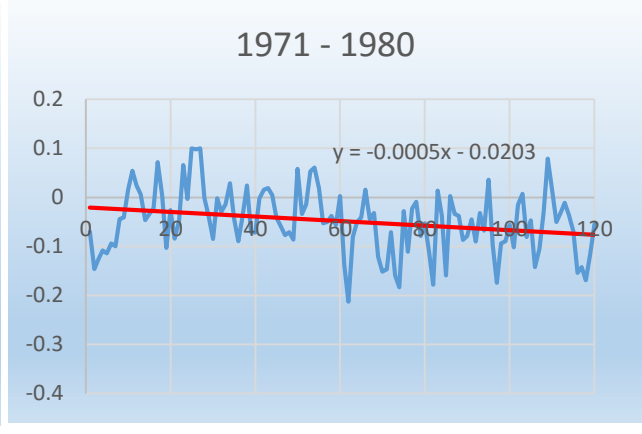
0.1
0
-0.1
-0.2
-0.3
-0.4
0
20
40
60
80
100
120


1971 - 1980
y = -0.0005x - 0.0203
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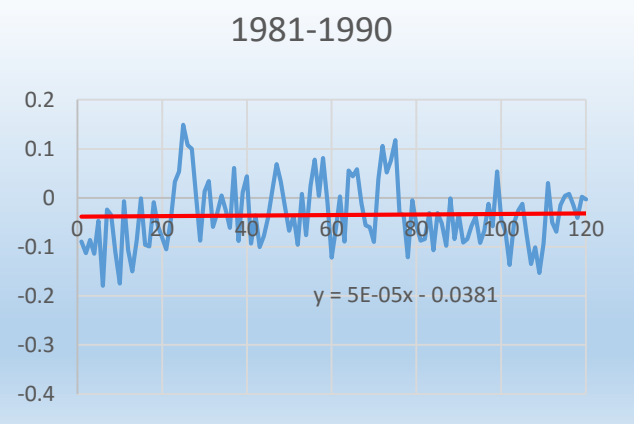
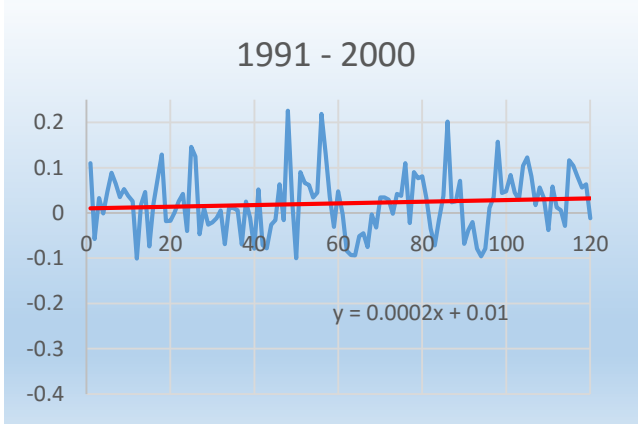
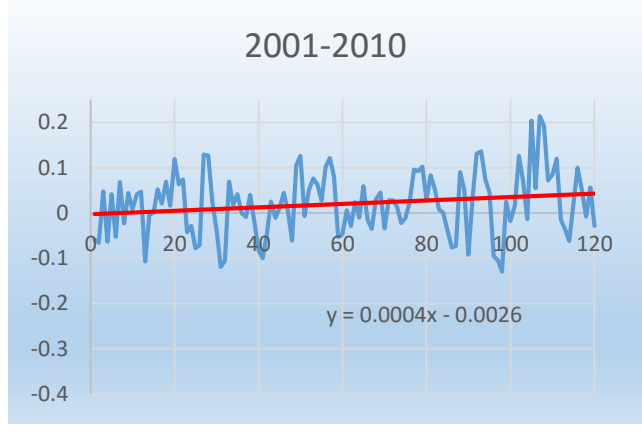
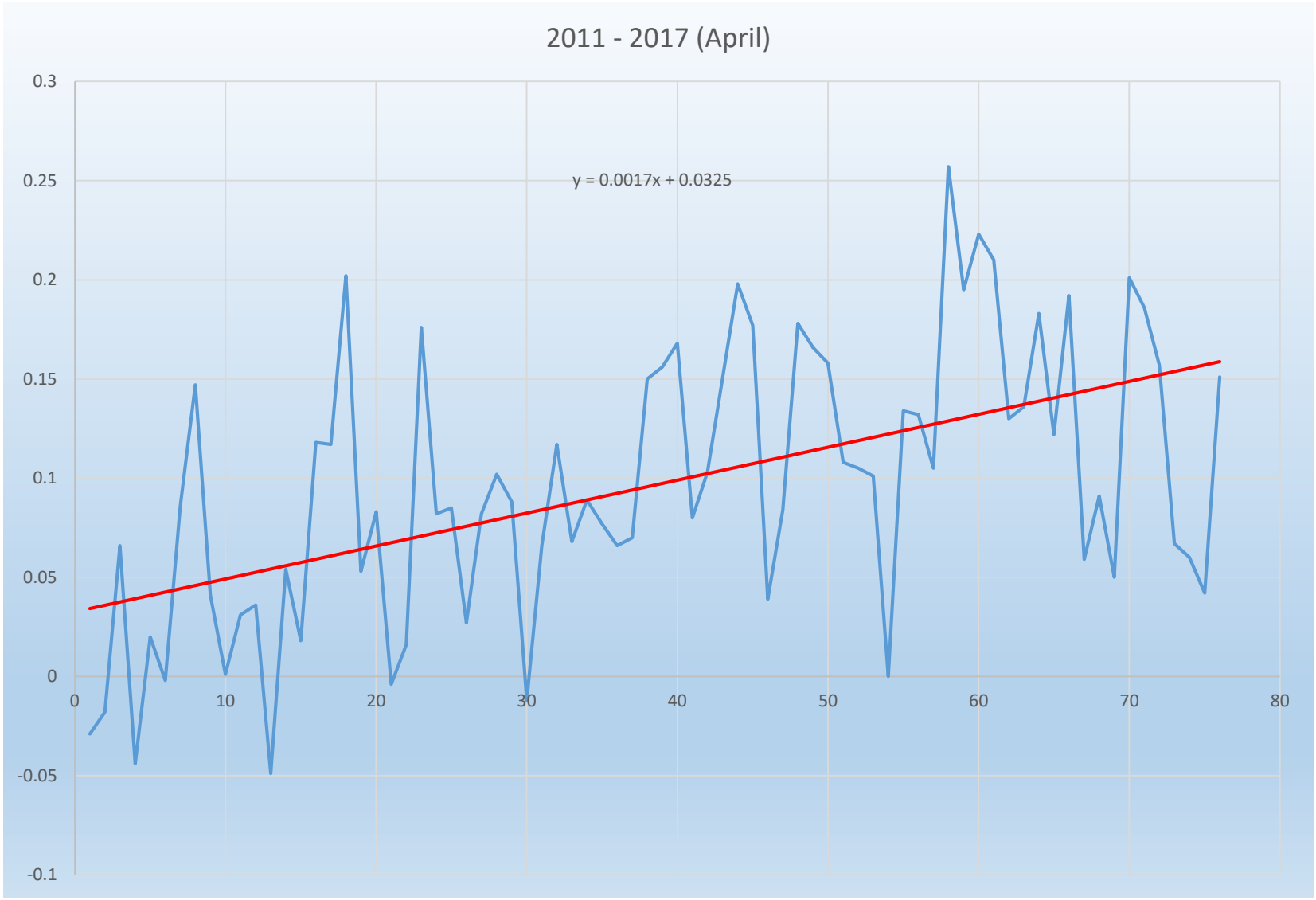
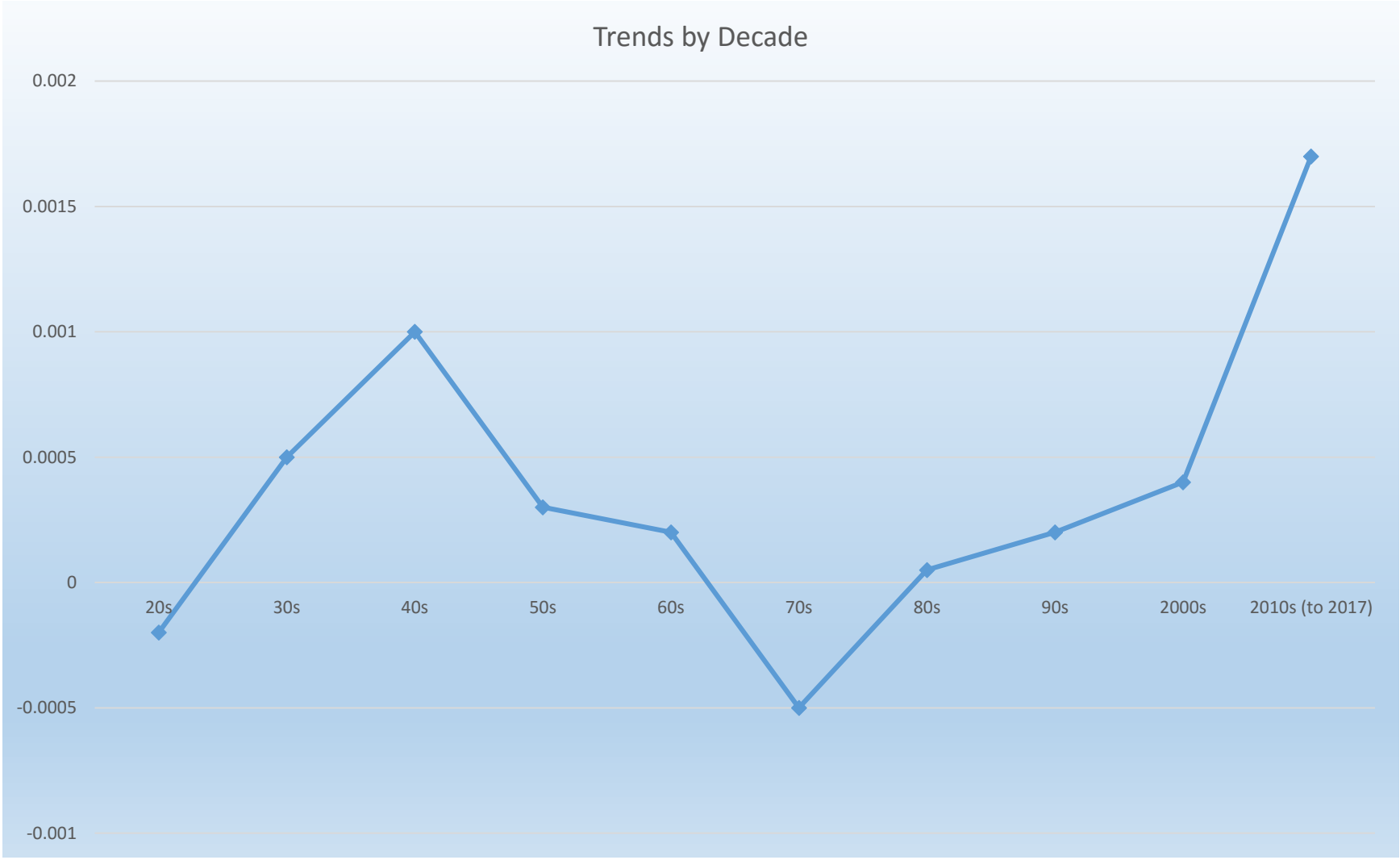
0.1
0
-0.1
-0.2
-0.3
-0.4
0
20
40
60
80
100
120


1981-1990
y = 5E-05x - 0.0381
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
0
20
40
60
80
100
120

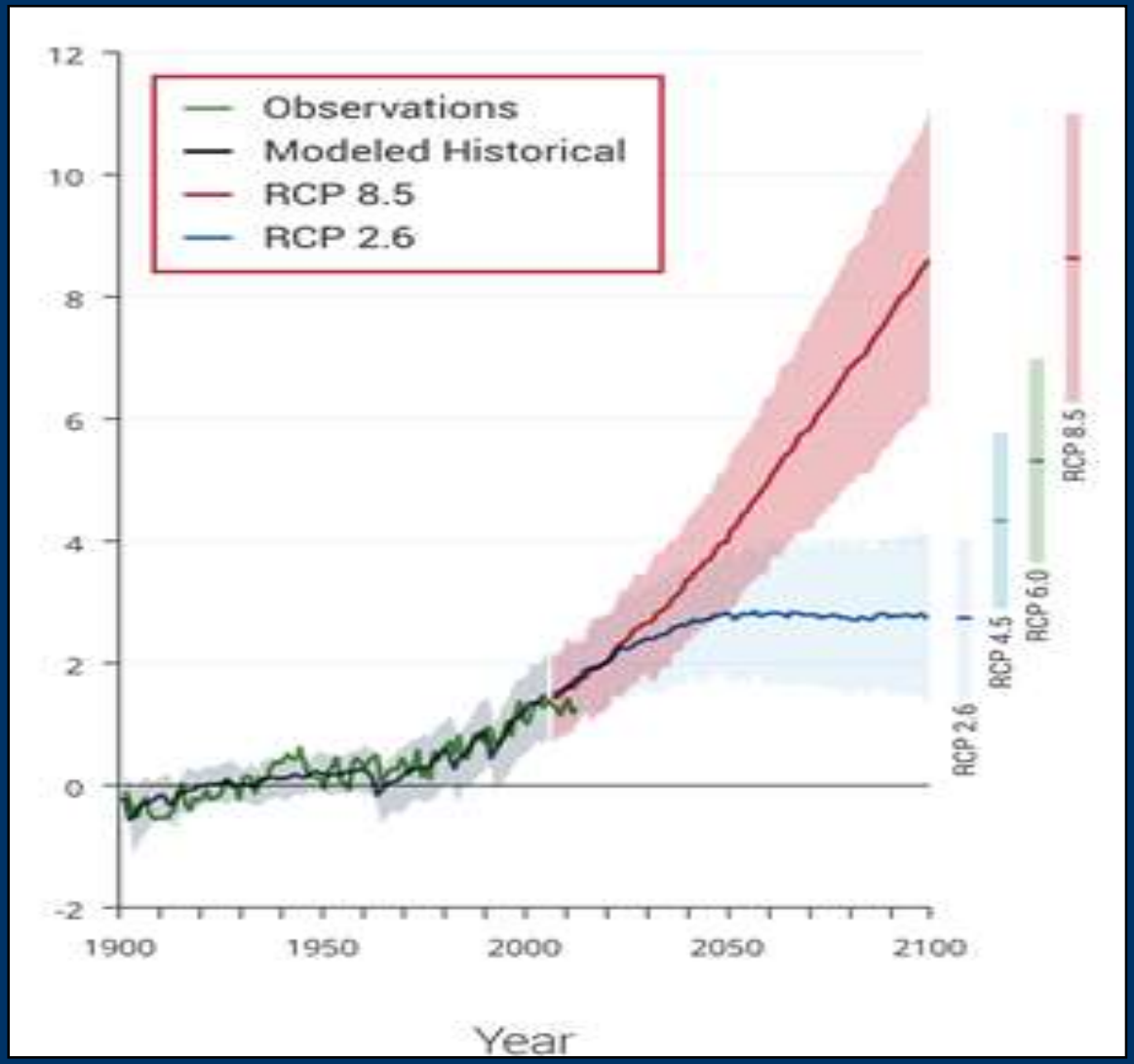

1991 - 2000
y = 0.0002x + 0.01
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
0
20
40
60
80
100
120


2001-2010
y = 0.0004x - 0.0026
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
0
20
40
60
80
100
120

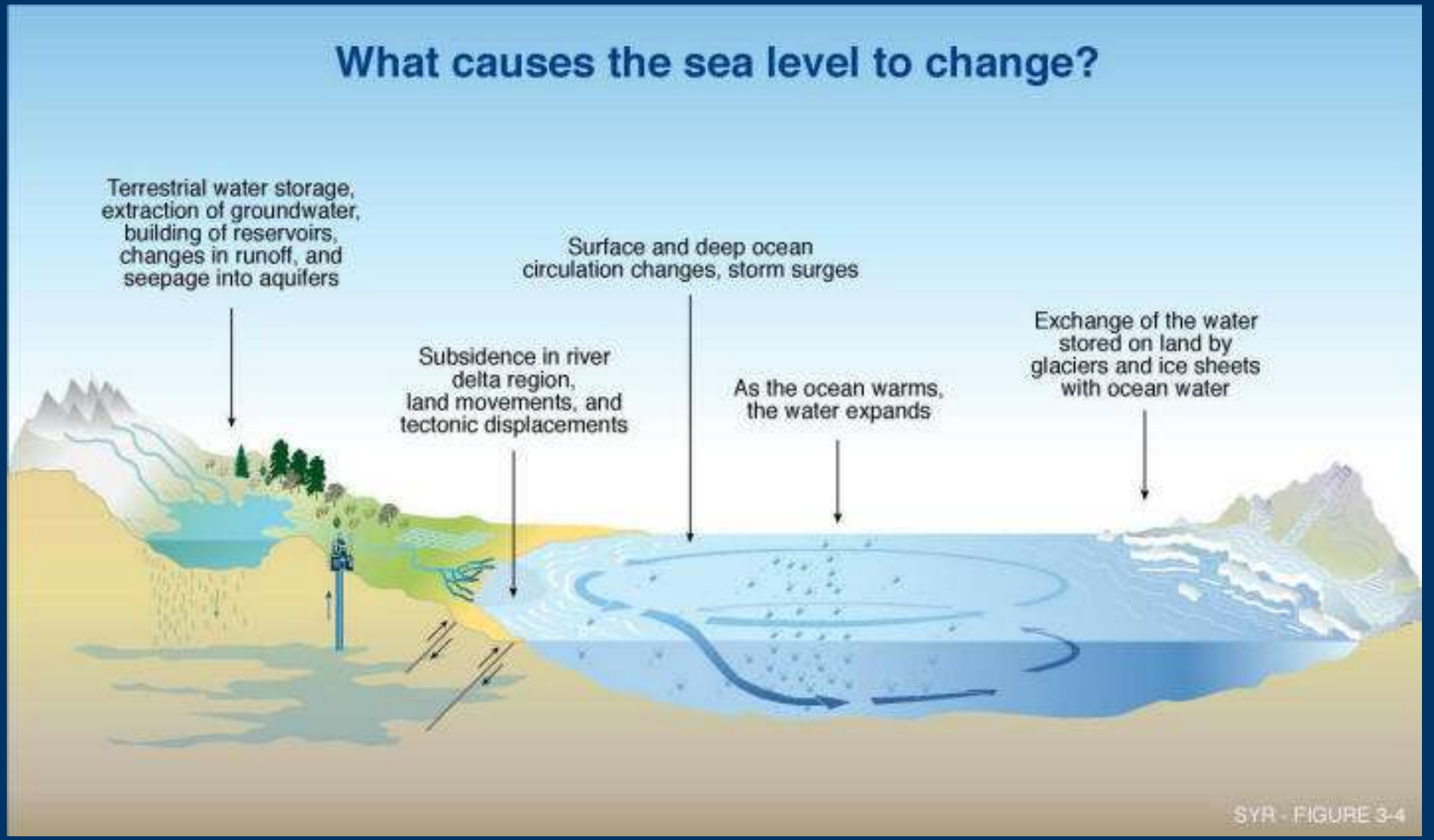

2011 - 2017 (April)
y = 0.0017x + 0.0325
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
0
10
20
30
40
50
60
70
80


Trends by Decade
0.002
0.0015
0.001
0.0005
0
-0.0005
-0.001
20s
30s
40s
50s
60s
70s
80s
90s
2000s
2010s (to 2017)

Future Temperature



Sea Level Change



Past, Present, and Future

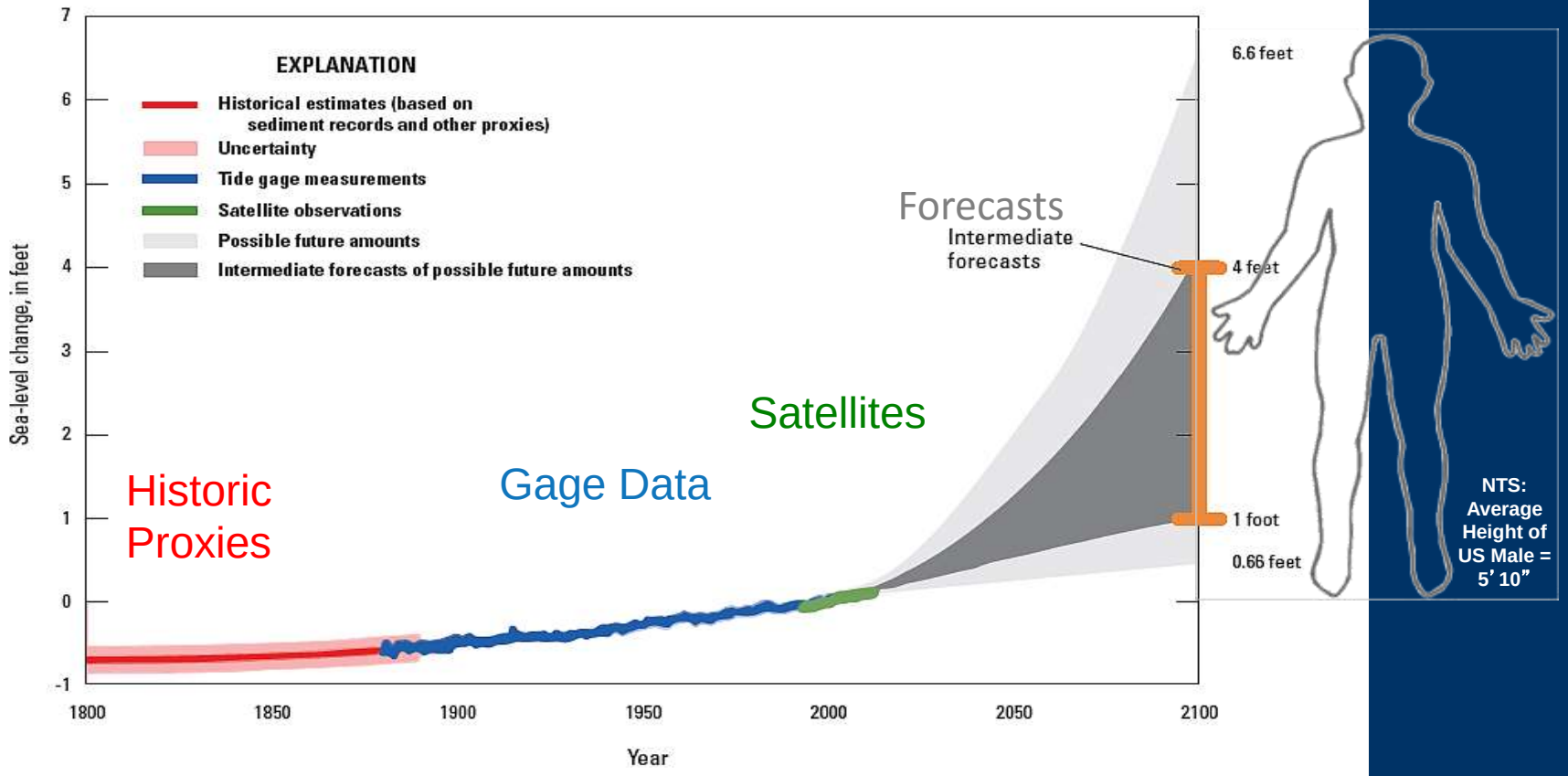
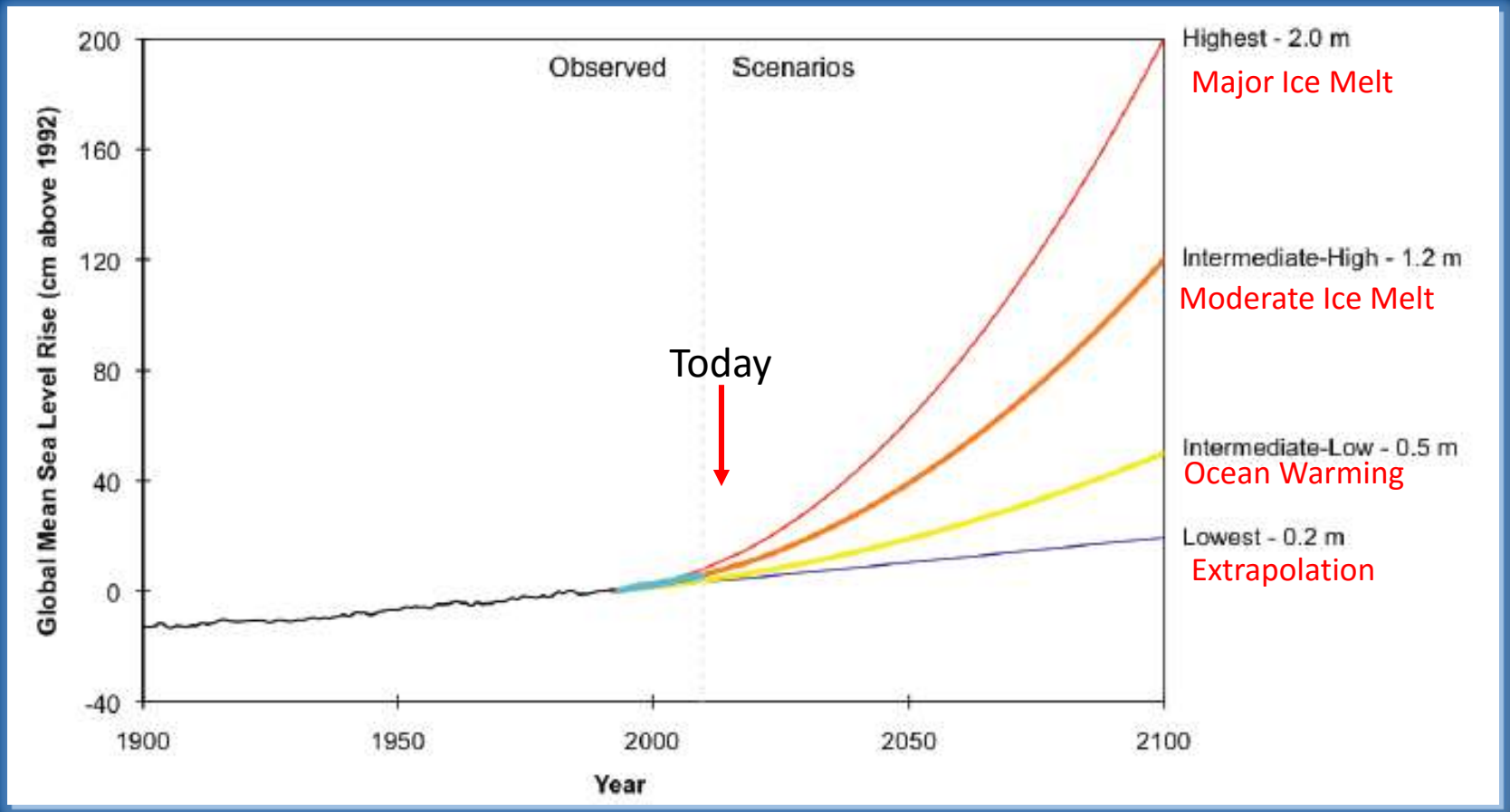


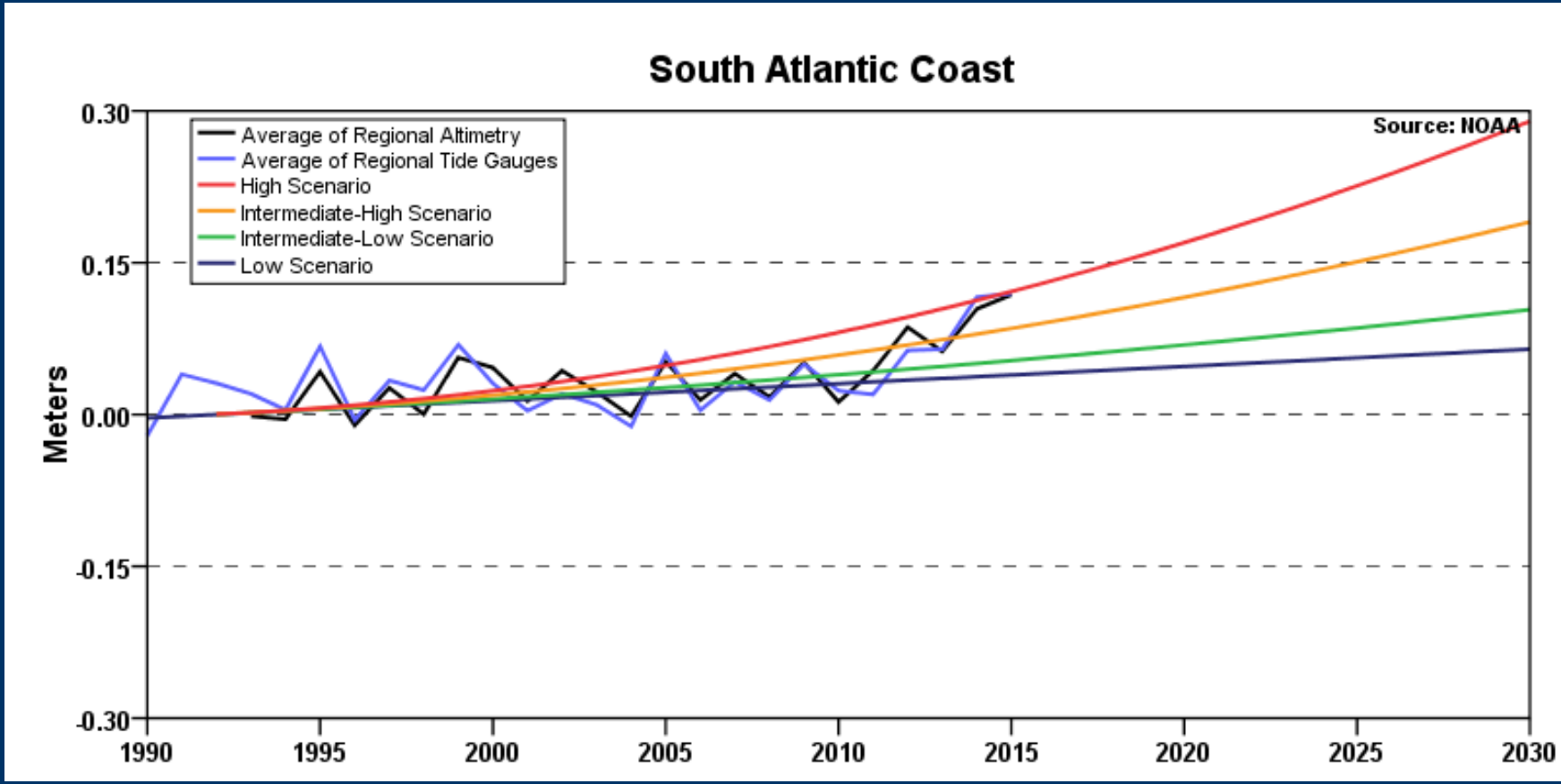
Figure 9. Historical, observed, and possible future amounts of global sea-level rise from 1800 to 2100 (from Melillo and others, 2014). Historical estimates (based on sediment records and other proxies) are shown in red (pink band shows uncertainty range), tide gage measurements in blue, and satellite observations in green.

“Consensus Scenarios” that fed the NCA 3rd Assessment

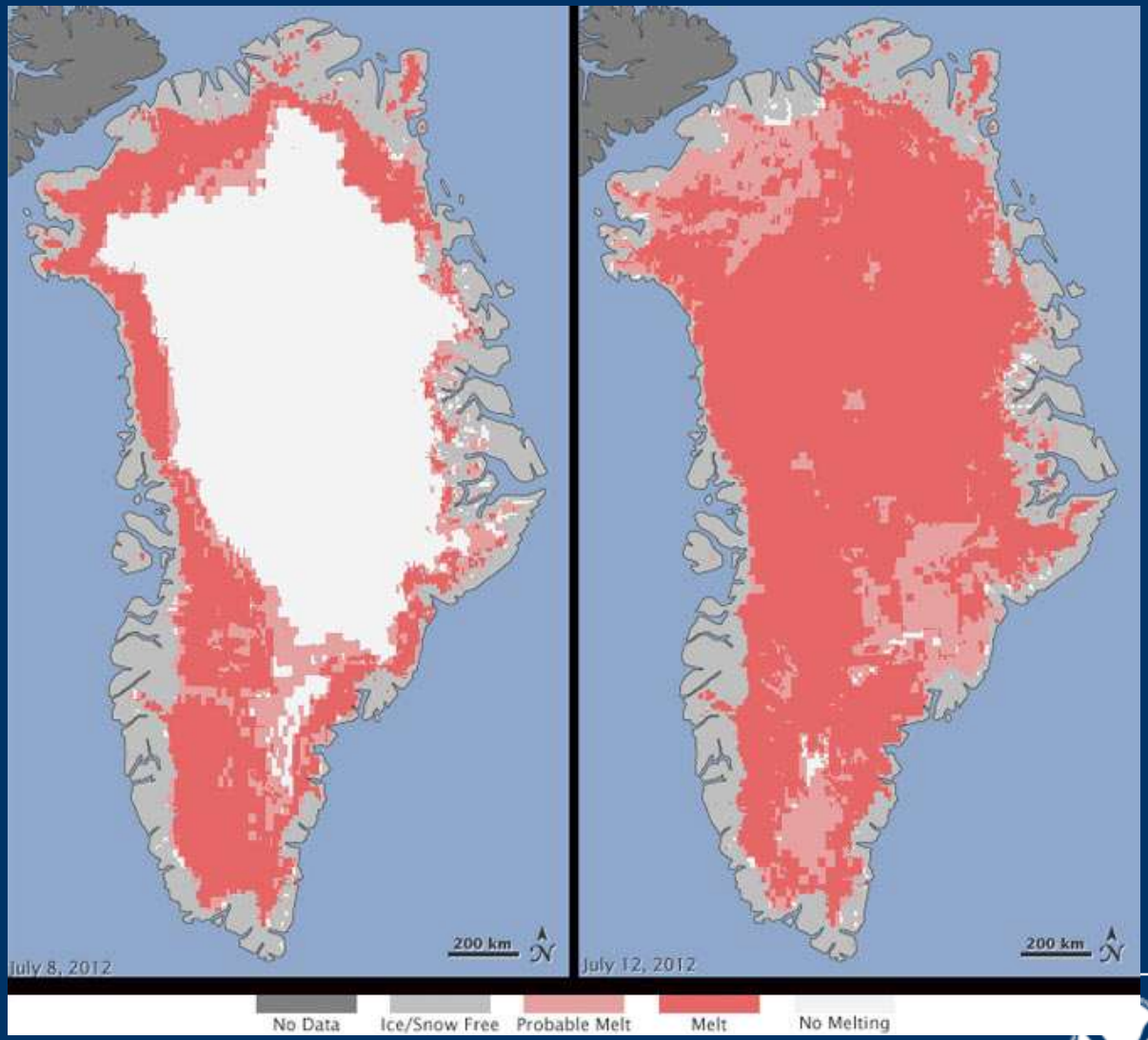
http://cpo.noaa.gov/sites/cpo/Reports/2012/NOAA_SLR_r3.pdf



How are We Tracking?



Greatest source of uncertainty?

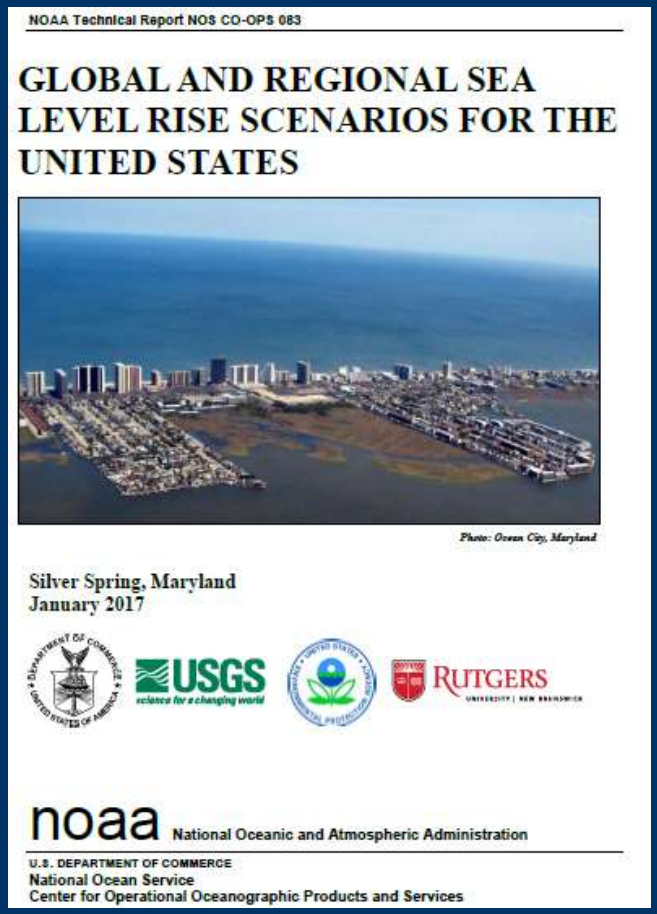


New Global and Regional Scenarios

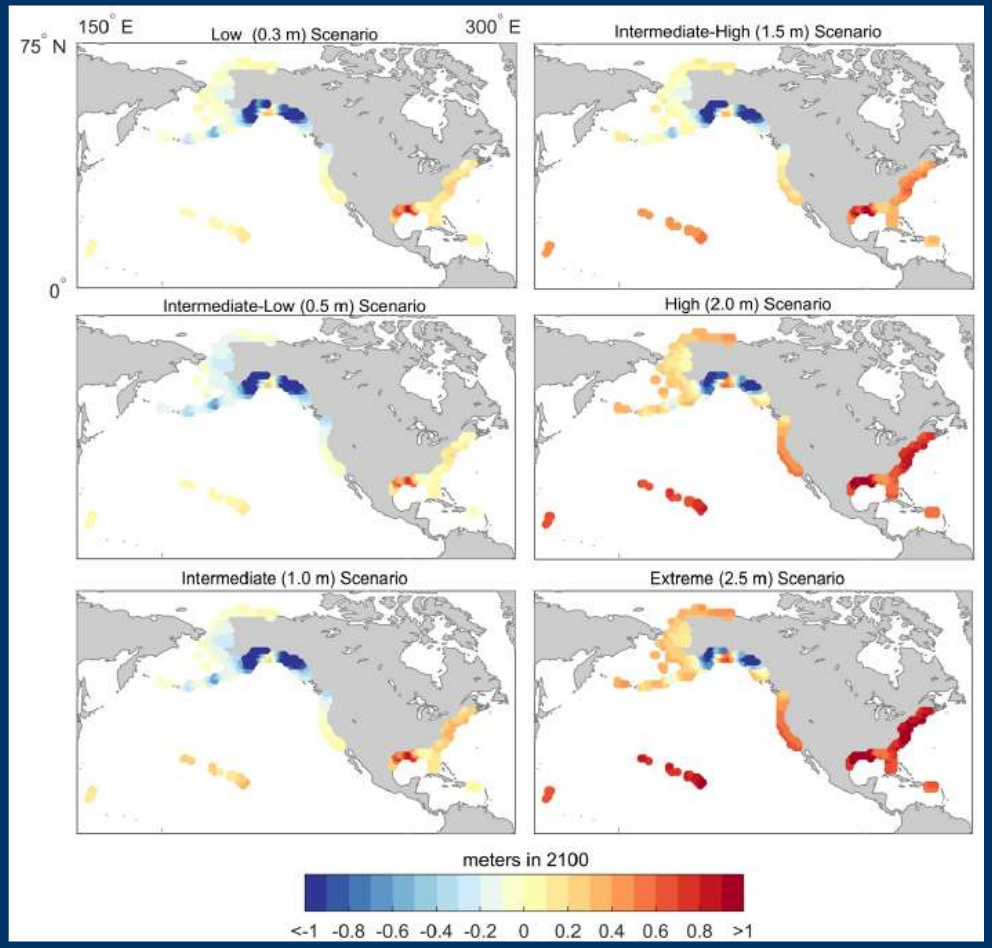
https://tidesandcurrents.noaa.gov/publications/techrpt83_Global_and_Regional_SLR_Scenarios_for_the_US_final.pdf

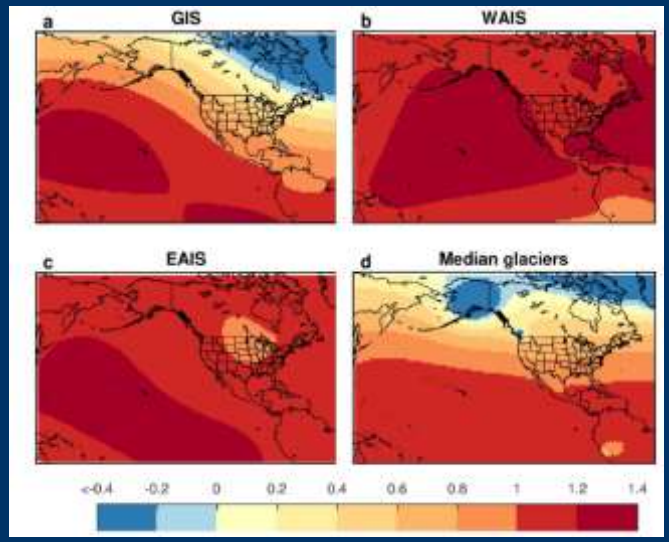
GMSL Scenario (meters)	2010	2020	2030	2040	2050	2060	2070	2080	2090	2100	2120	2150	2200
Low	0.03	0.06	0.09	0.13	0.16	0.19	0.22	0.25	0.28	0.30	0.34	0.37	0.39
Intermediate-Low	0.04	0.08	0.13	0.18	0.24	0.29	0.35	0.4	0.45	0.50	0.60	0.73	0.95
Intermediate	0.04	0.10	0.16	0.25	0.34	0.45	0.57	0.71	0.85	1.0	1.3	1.8	2.8
Intermediate-High	0.05	0.10	0.19	0.30	0.44	0.60	0.79	1.0	1.2	1.5	2.0	3.1	5.1
High	0.05	0.11	0.21	0.36	0.54	0.77	1.0	1.3	1.7	2.0	2.8	4.3	7.5
Extreme	0.04	0.11	0.24	0.41	0.63	0.90	1.2	1.6	2.0	2.5	3.6	5.5	9.7

GMSL Scenario Rates (mm/year)	2010	2020	2030	2040	2050	2060	2070	2080	2090
Low	3	3	3	3	3	3	3	3	3
Intermediate-Low	4	5	5	5	5	5	5	5	5
Intermediate	5	6	7	9	10	12	13	14	15
Intermediate-High	5	7	10	13	15	18	20	22	24
High	6	8	13	16	20	24	28	31	35
Extreme	6	10	15	20	25	30	35	40	44



Relative Sea Level Rise





GMSL adjusted for

1.) Oceanographic Factors

2.) Gravity Changes due to Melting Land Based Ice

3.) Vertical Land Movement

Probabilities Related to RCPs

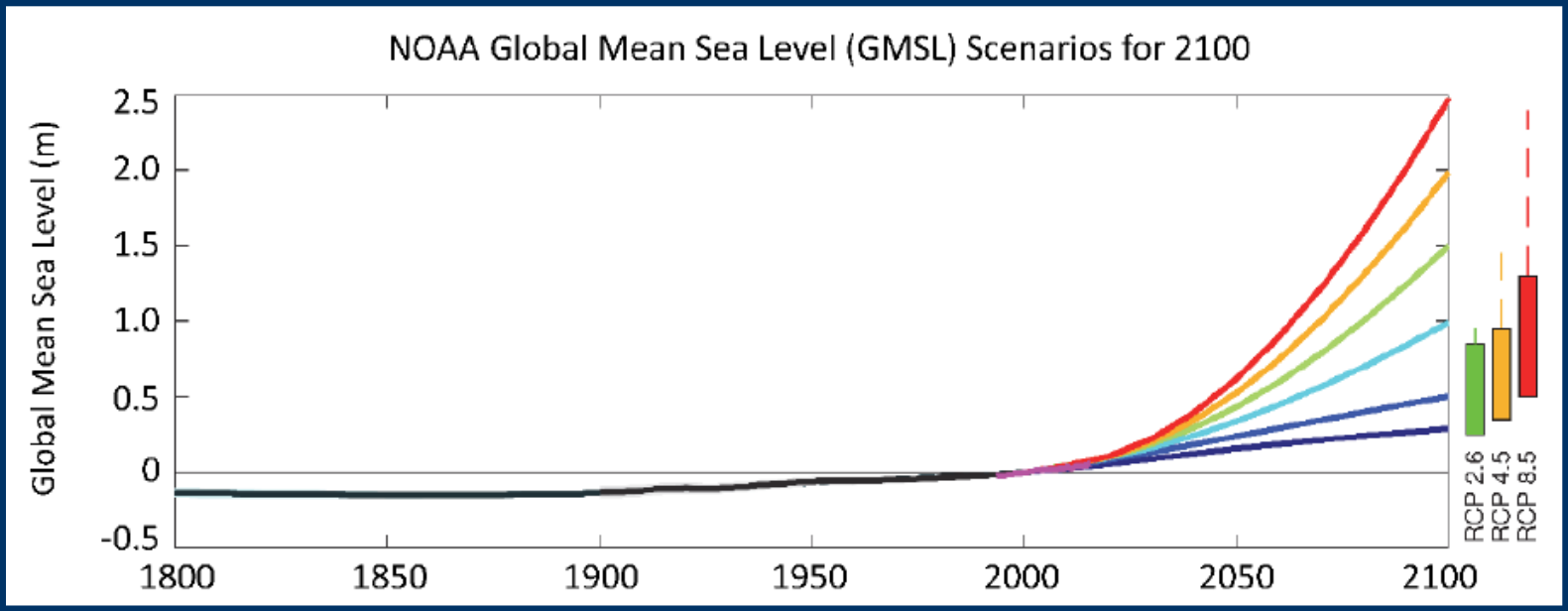
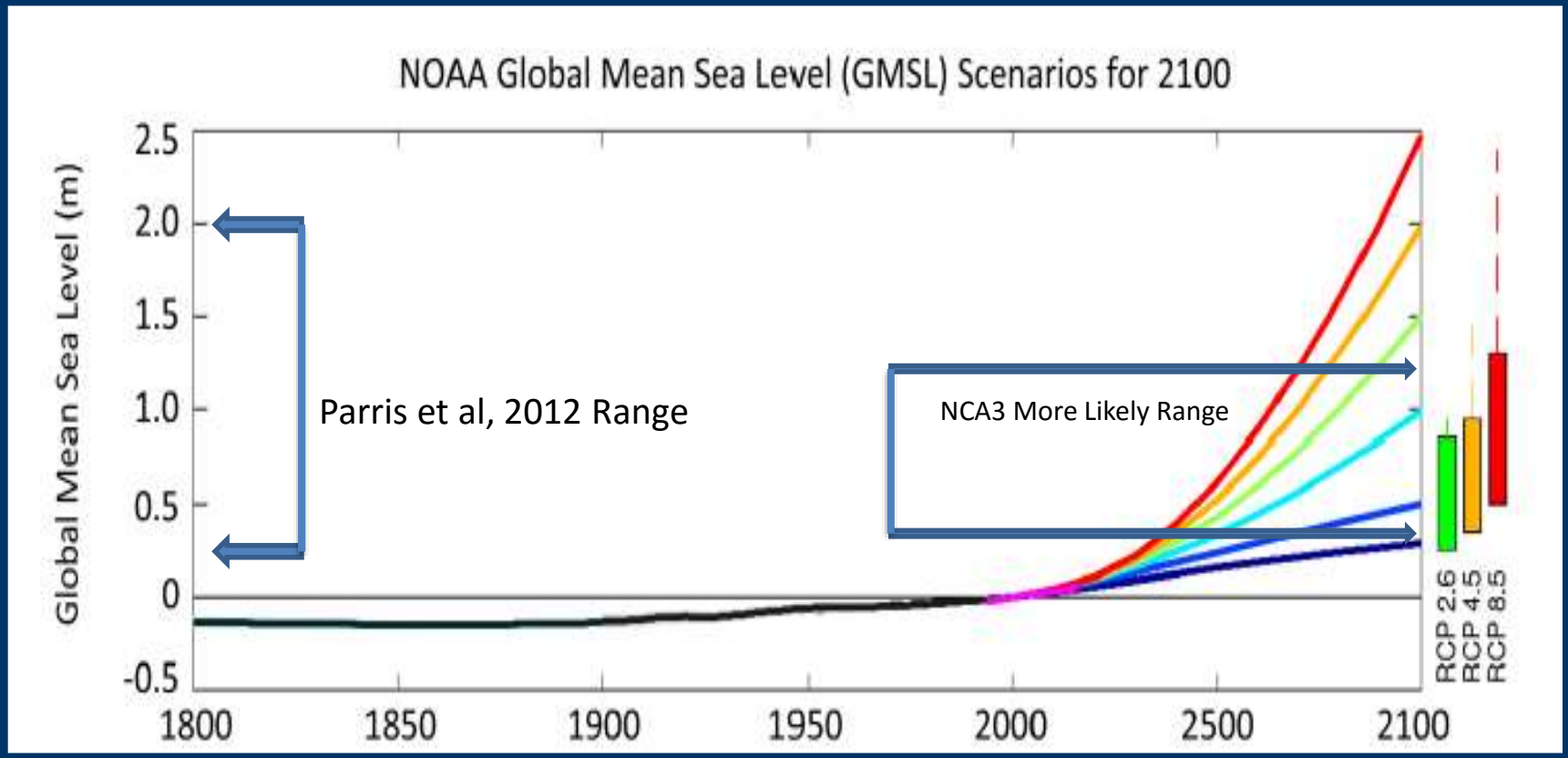


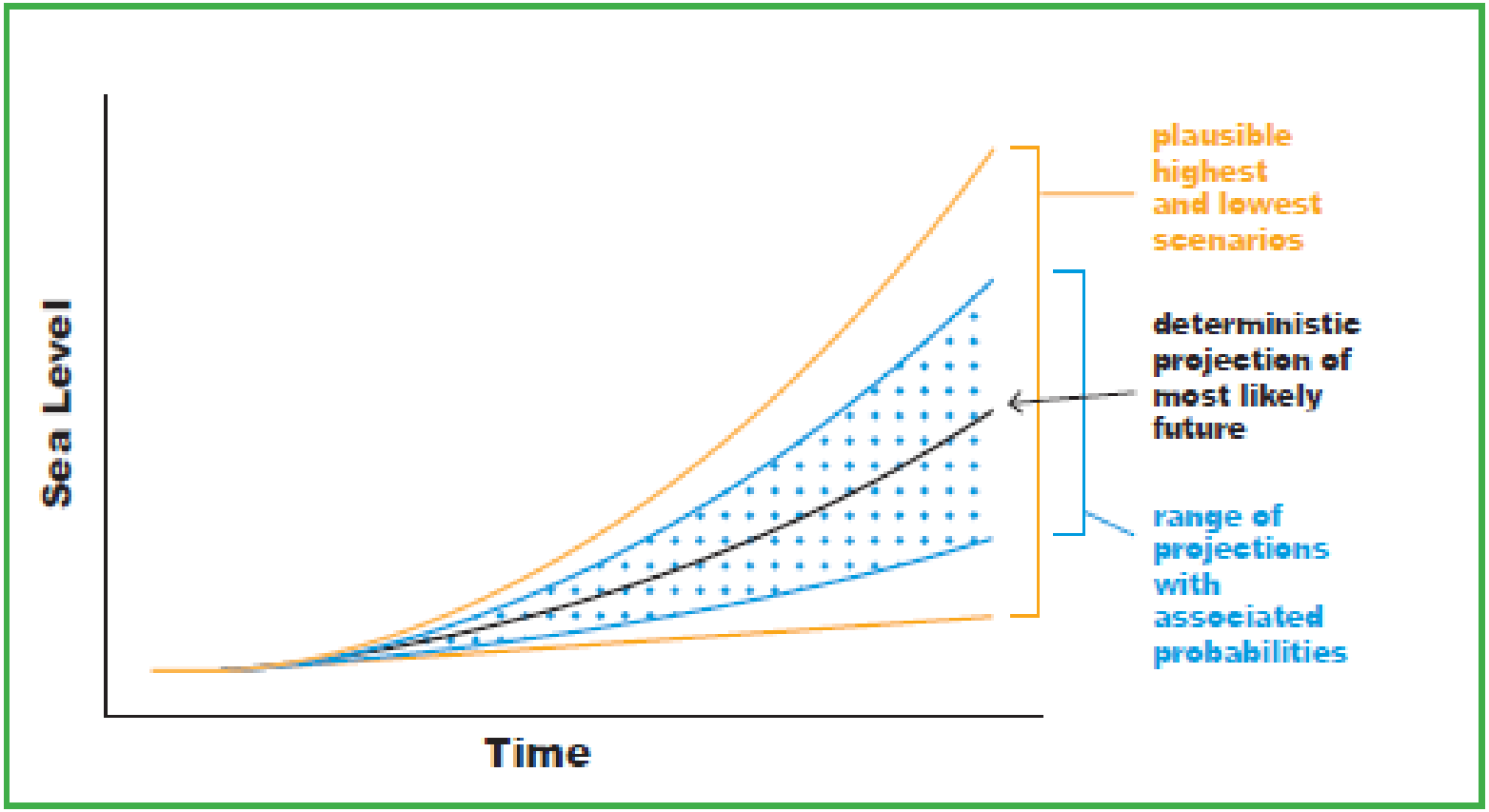
Table 4. Probability of exceeding GMSL (median value) scenarios in 2100 based upon Kopp et al. (2014).

GMSL rise Scenario	RCP2.6	RCP4.5	RCP8.5
Low (0.3 m)	94%	98%	100%
Intermediate-Low (0.5 m)	49%	73%	96%
Intermediate (1.0 m)	2%	3%	17%
Intermediate-High (1.5 m)	0.4%	0.5%	1.3%
High (2.0 m)	0.1%	0.1%	0.3%
Extreme (2.5 m)	0.05%	0.05%	0.1%

How Do The New Ones Compare?



Deterministic, Probabilistic, Plausible Scenarios

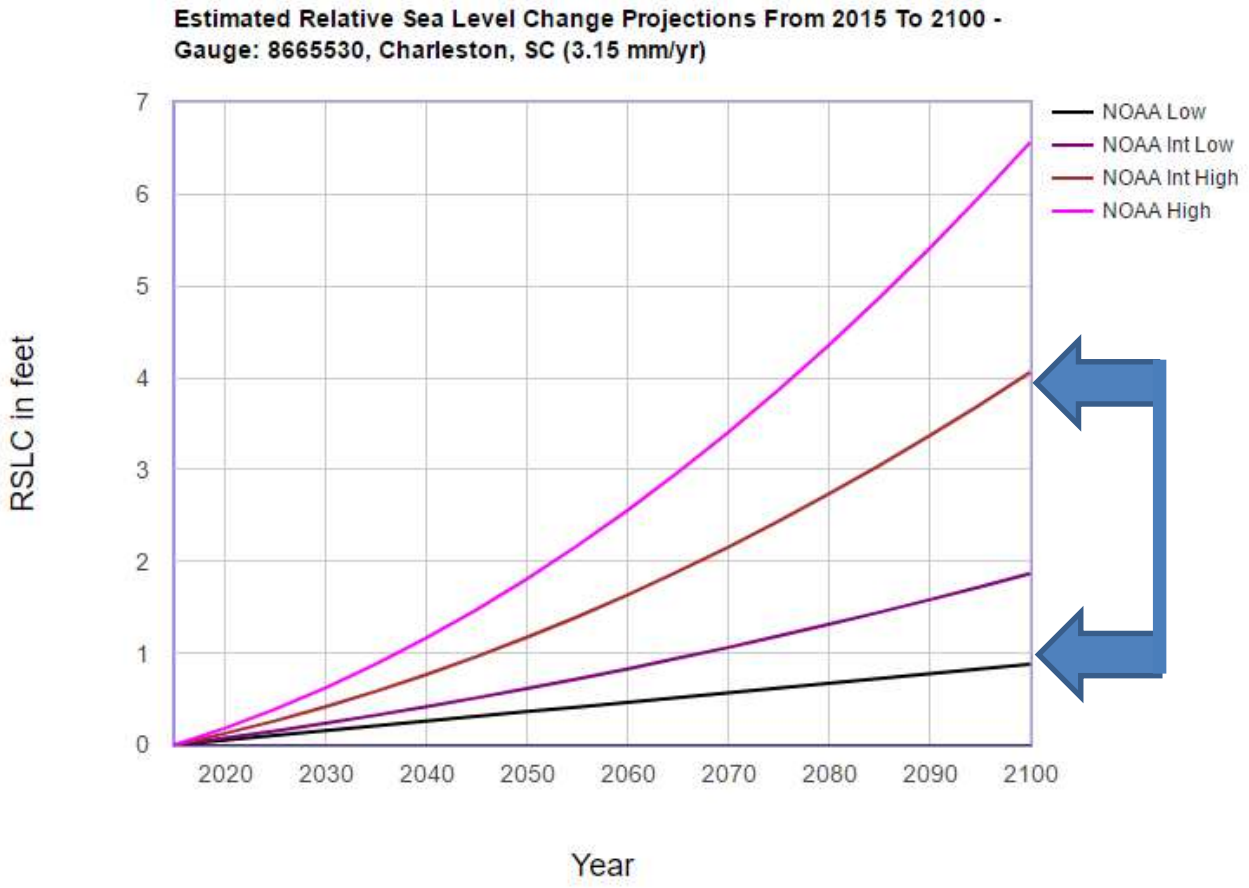


Previous Curves

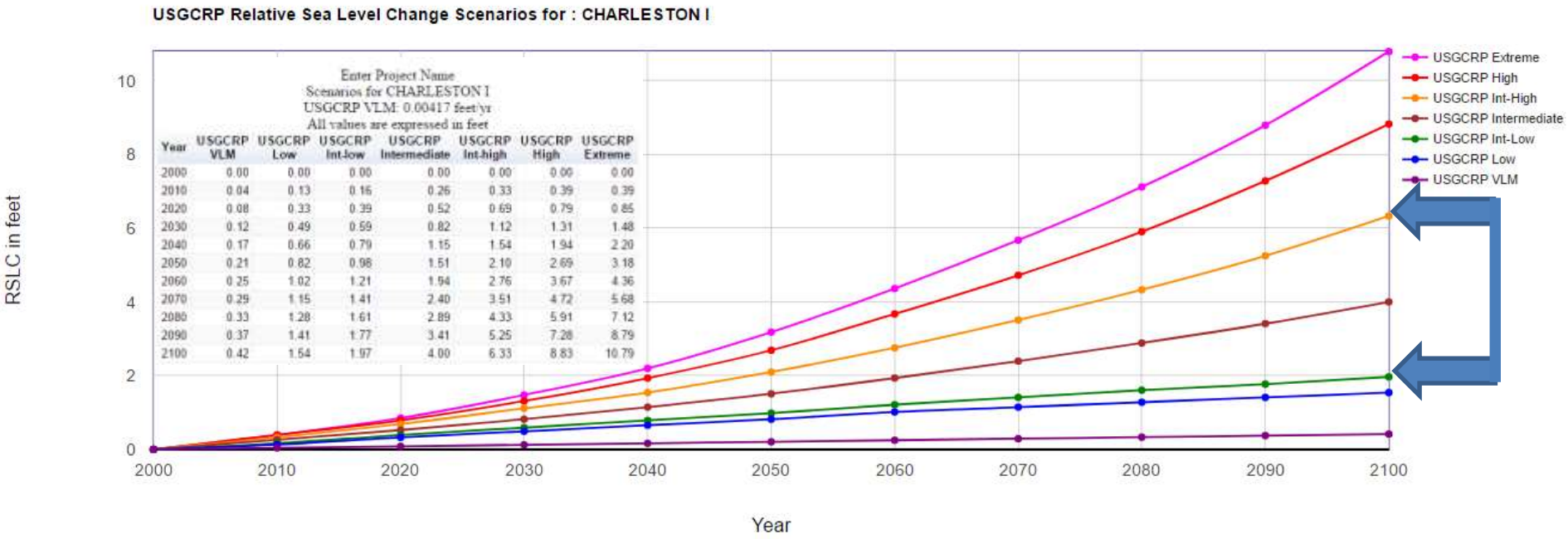
Estimated Relative Sea Level Change from 2015 To 2100
8665530, Charleston, SC
NOAA's Published Rate: 0.01033 feet/yr
All values are expressed in feet

Year	NOAA Low	NOAA Int Low	NOAA Int High	NOAA High
2015	0.0	0.0	0.0	0.0
2020	0.1	0.1	0.1	0.2
2025	0.1	0.2	0.3	0.4
2030	0.2	0.2	0.4	0.6
2035	0.2	0.3	0.6	0.9
2040	0.3	0.4	0.8	1.2
2045	0.3	0.5	1.0	1.5
2050	0.4	0.6	1.2	1.8
2055	0.4	0.7	1.4	2.2
2060	0.5	0.8	1.6	2.6
2065	0.5	0.9	1.9	3.0
2070	0.6	1.1	2.2	3.4
2075	0.6	1.2	2.4	3.9
2080	0.7	1.3	2.7	4.4
2085	0.7	1.4	3.0	4.9
2090	0.8	1.6	3.4	5.4
2095	0.8	1.7	3.7	6.0
2100	0.9	1.9	4.1	6.6

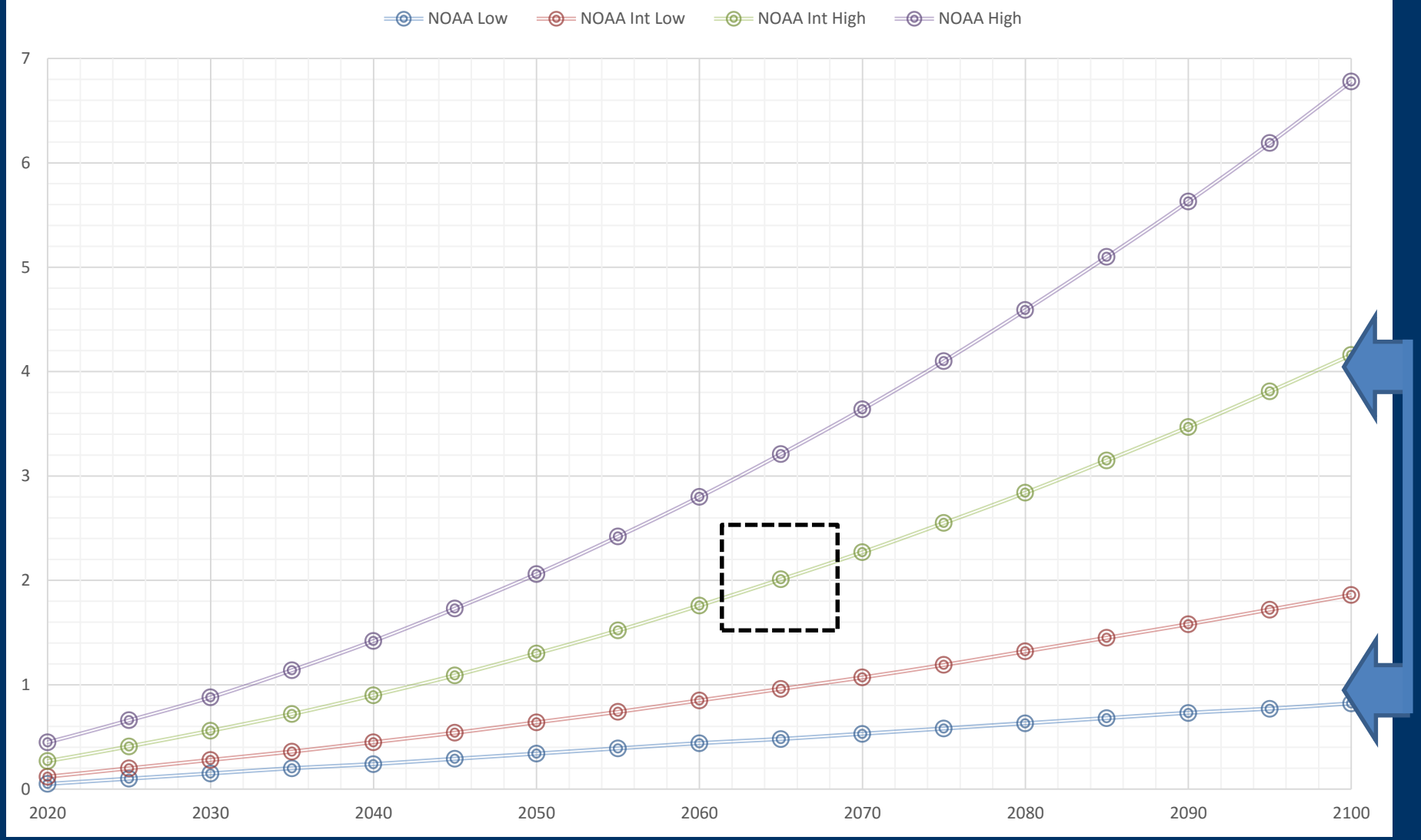
Print Table



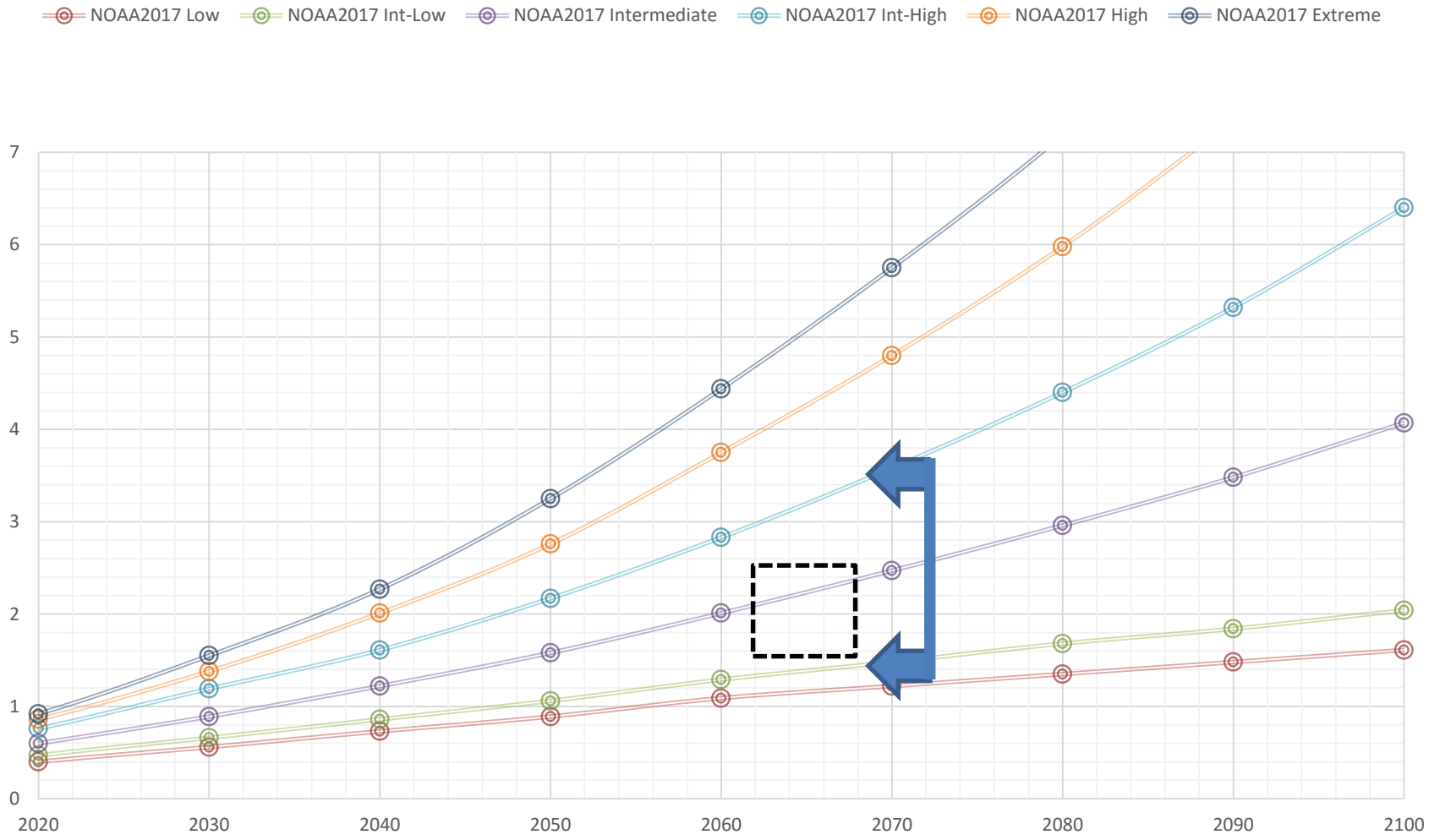
New Curves


USGCRP Relative Sea Level Change Scenarios for : CHARLESTON I
Enter Project Name
Scenarios for CHARLESTON I
USGCRP VLM: 0.00417 feet/yr
All values are expressed in feet
Year | USGCRP VLM | USGCRP Low | USGCRP Int-low | USGCRP Intermediate | USGCRP Int-high | USGCRP High | USGCRP Extreme
2000 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00
2010 | 0.04 | 0.13 | 0.16 | 0.26 | 0.33 | 0.39 | 0.39
2020 | 0.08 | 0.33 | 0.39 | 0.52 | 0.69 | 0.79 | 0.85
2030 | 0.12 | 0.49 | 0.59 | 0.82 | 1.12 | 1.31 | 1.48
2040 | 0.17 | 0.66 | 0.79 | 1.15 | 1.54 | 1.94 | 2.20
2050 | 0.21 | 0.82 | 0.98 | 1.51 | 2.10 | 2.69 | 3.18
2060 | 0.25 | 1.02 | 1.21 | 1.94 | 2.76 | 3.67 | 4.36
2070 | 0.29 | 1.15 | 1.41 | 2.40 | 3.51 | 4.72 | 5.68
2080 | 0.33 | 1.28 | 1.61 | 2.89 | 4.33 | 5.91 | 7.12
2090 | 0.37 | 1.41 | 1.77 | 3.41 | 5.25 | 7.28 | 8.79
2100 | 0.42 | 1.54 | 1.97 | 4.00 | 6.33 | 8.83 | 10.79
RSLC in feet
0
2
4
6
8
10
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100
Year
USGCRP Extreme
USGCRP High
USGCRP Int-High
USGCRP Intermediate
USGCRP Int-Low
USGCRP Low
USGCRP VLM

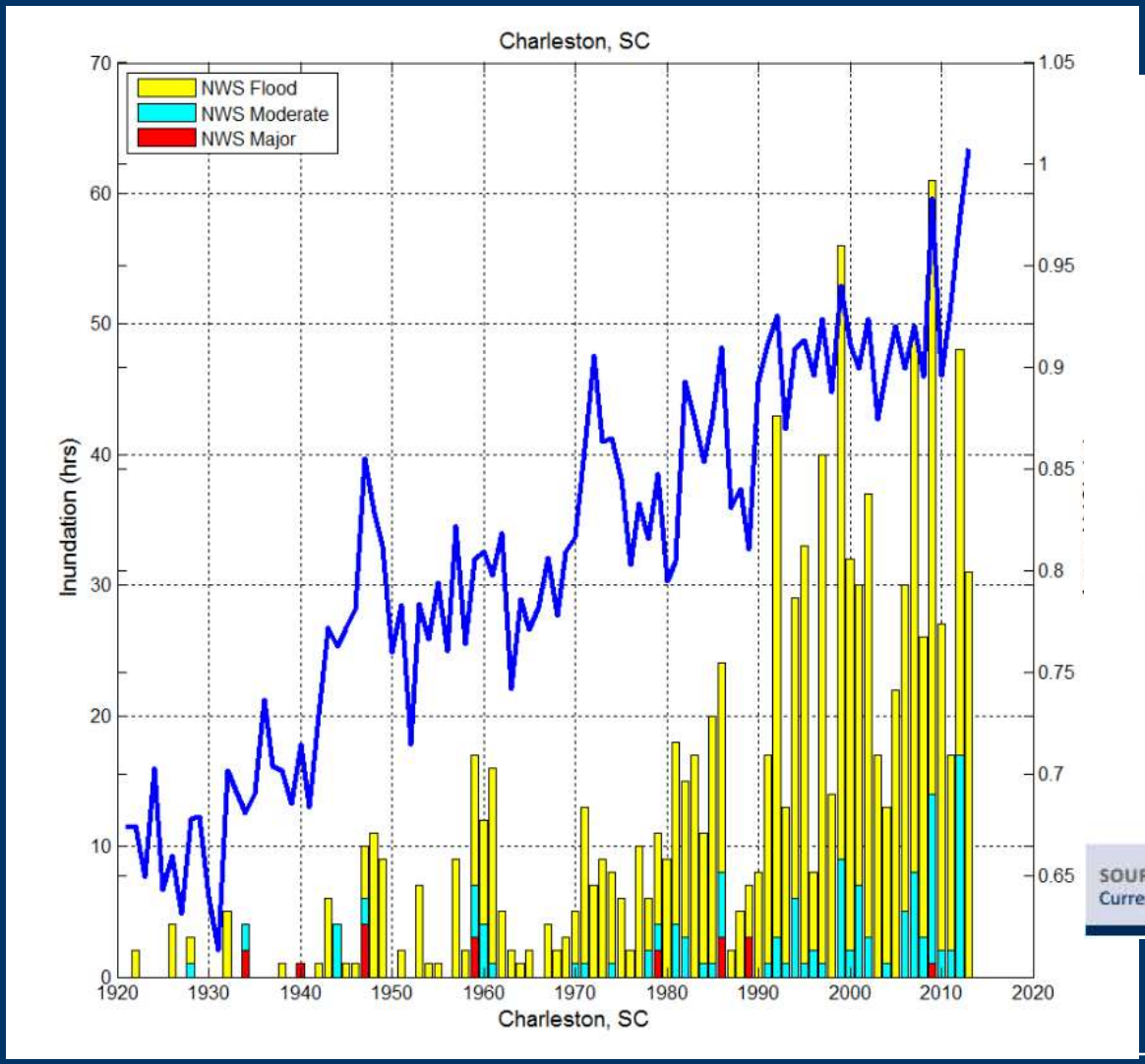
NCA3 Scenarios for Charleston, SC

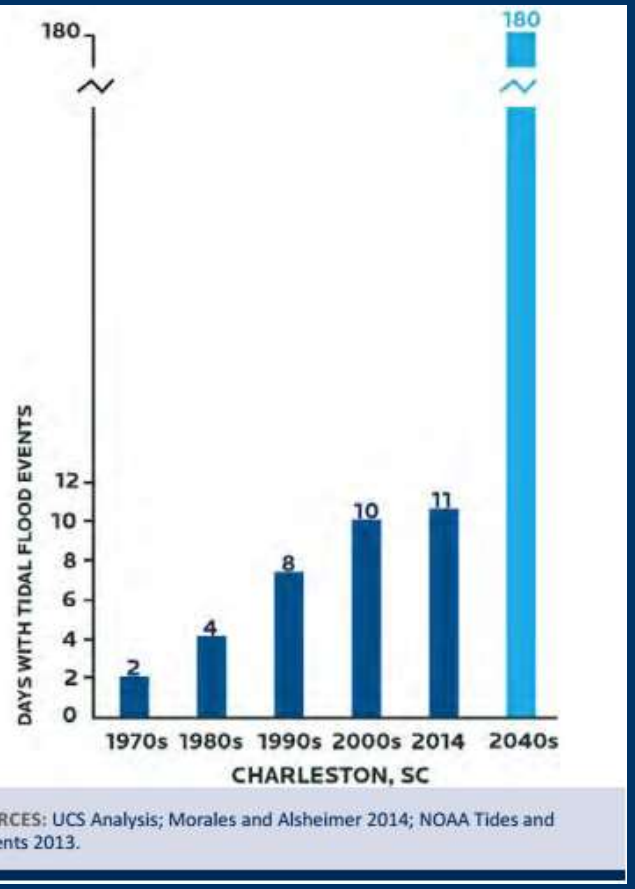


NCA4 Scenarios for Charleston, SC



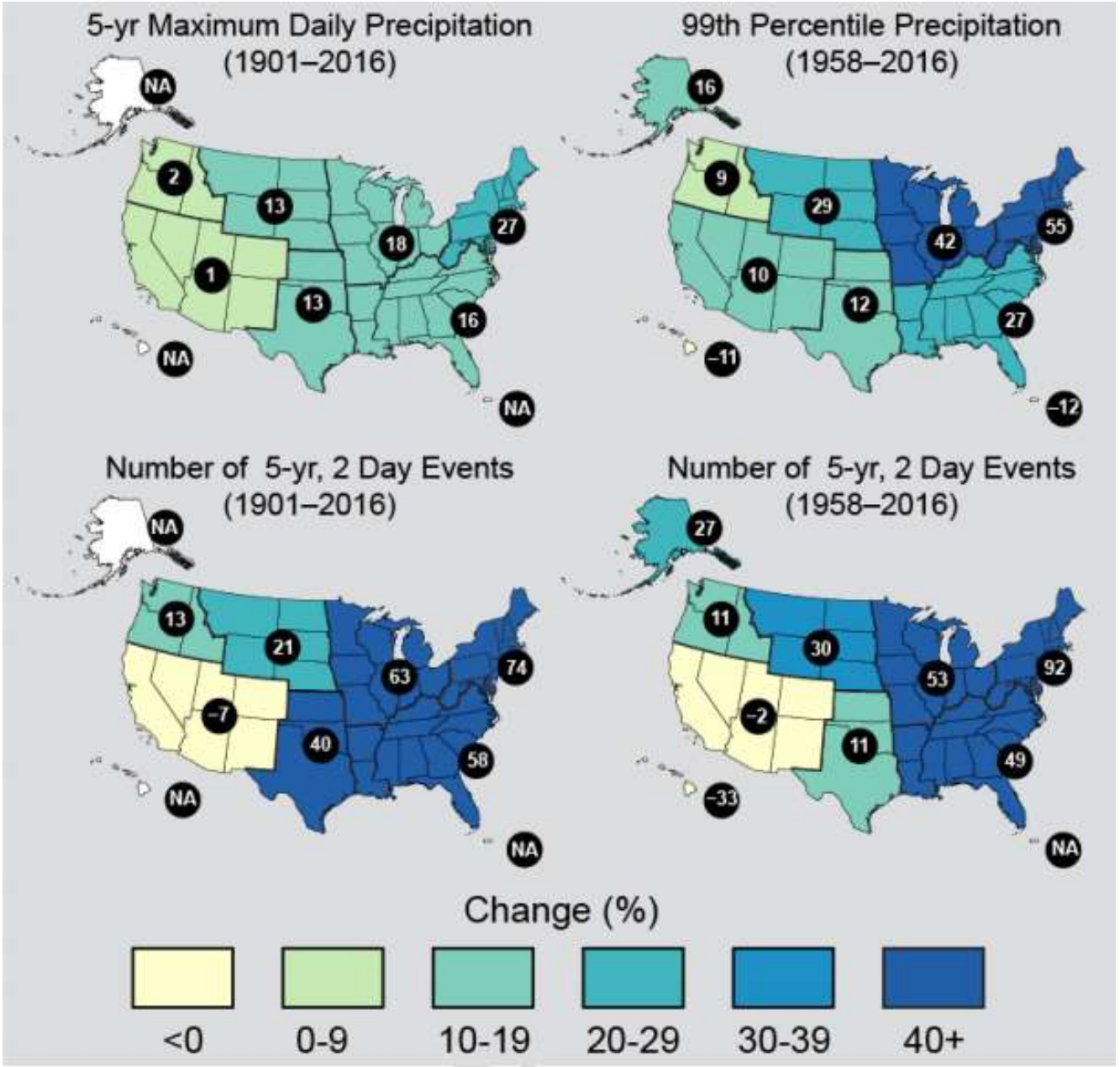
Increase in High Tide Flooding Events



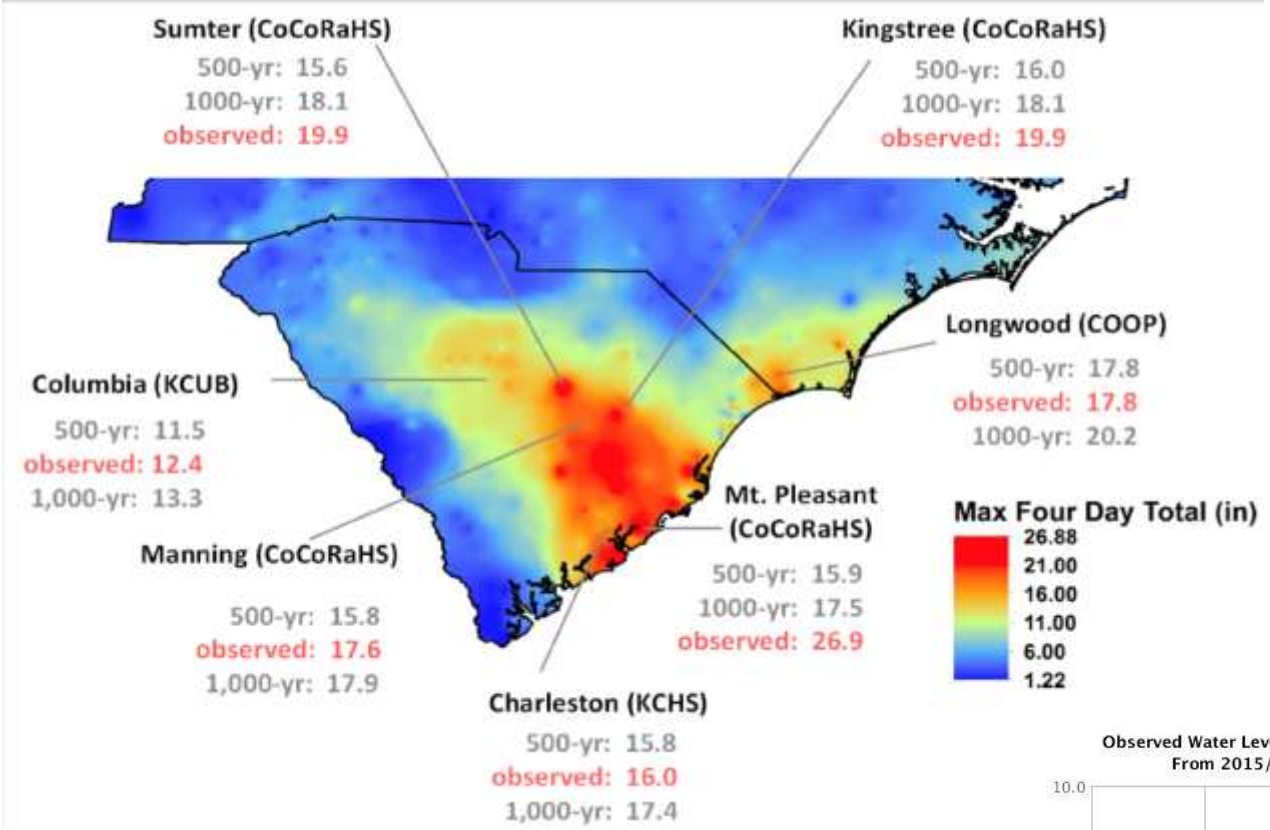


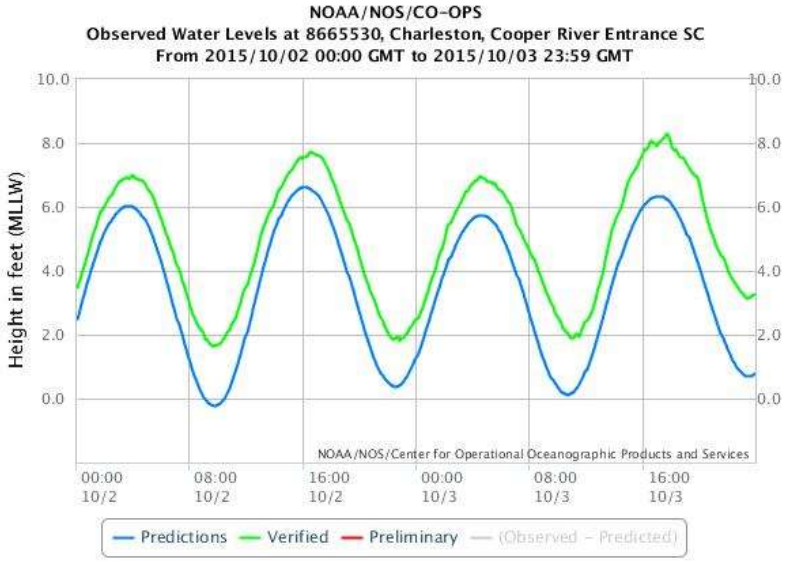
From Sweet et al., 2014

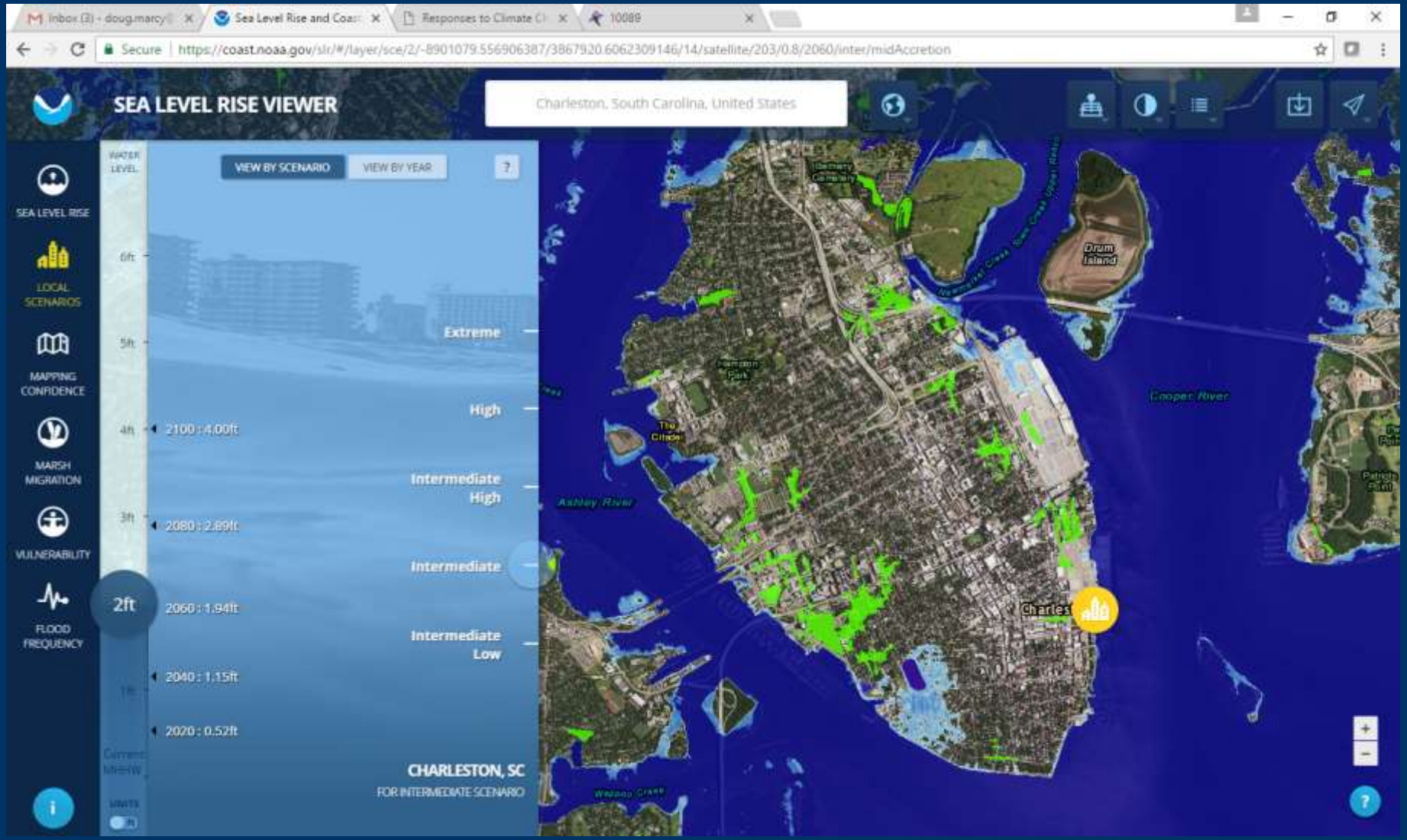
Extreme Precipitation

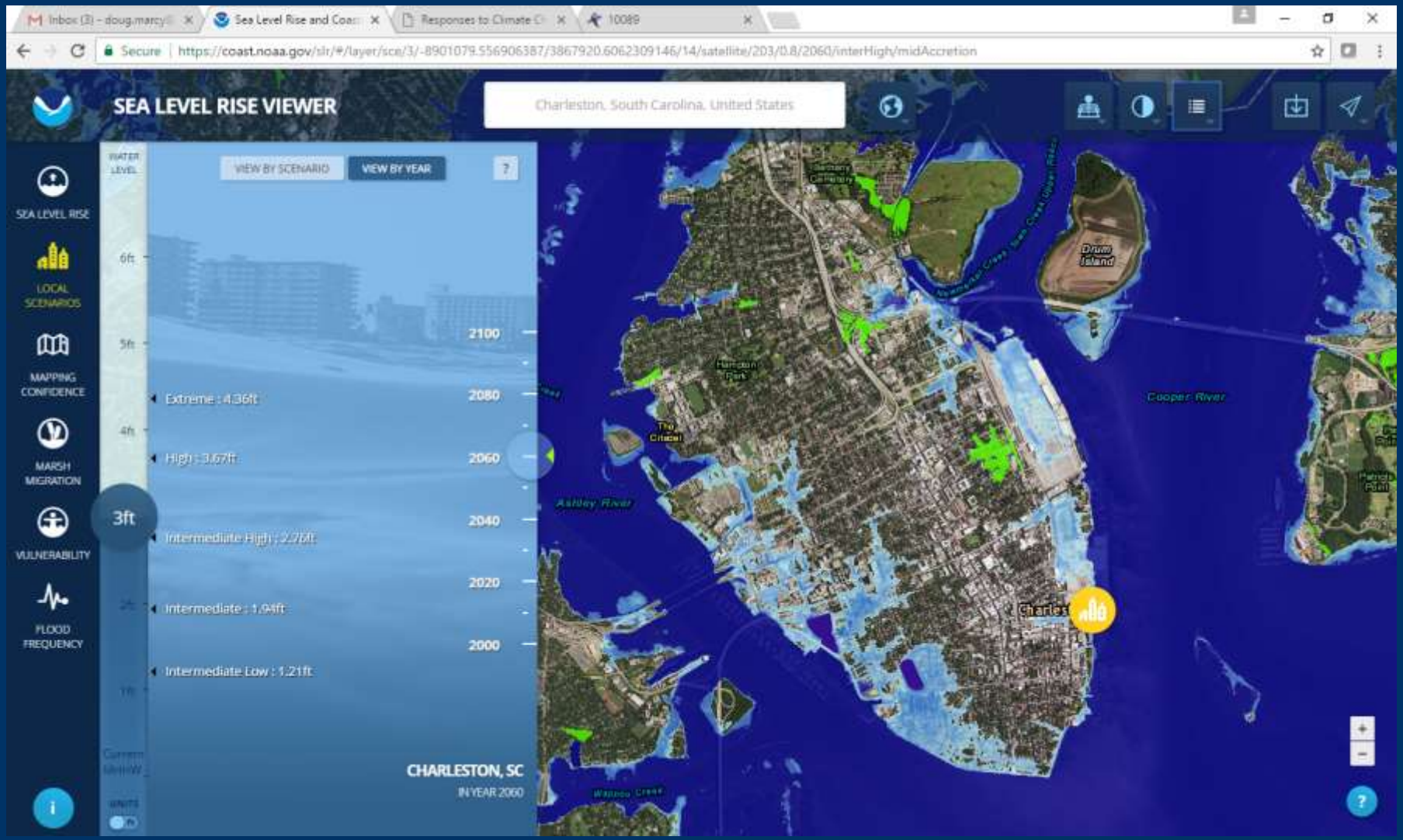


Combined Events – October 2015



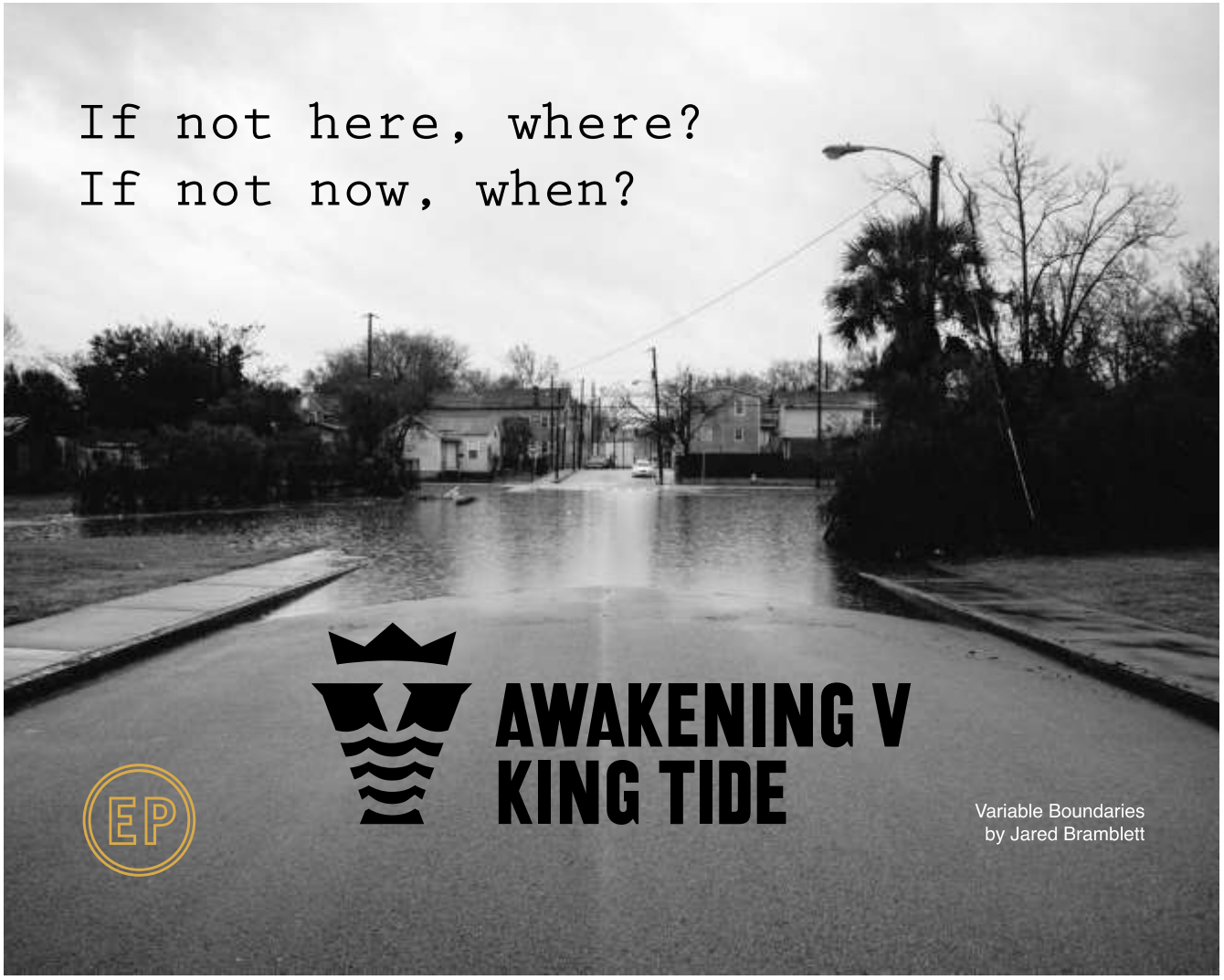



SEA LEVEL RISE VIEWER
Charleston, South Carolina, United States
VIEW BY SCENARIO
VIEW BY YEAR
SEA LEVEL RISE
LOCAL SCENARIOS
MAPPING CONFIDENCE
MARSH MIGRATION
VULNERABILITY
FLOOD FREQUENCY
6ft
5ft
4ft
3ft
2ft
1ft
Extreme
High
2100 : 4.00ft
Intermediate High
2080 : 2.89ft
Intermediate
2060 : 1.94ft
Intermediate Low
2040 : 1.15ft
2020 : 0.52ft
CHARLESTON, SC
FOR INTERMEDIATE SCENARIO
Drum Island
Cooper River
Ashley River
Charles


SEA LEVEL RISE VIEWER
Charleston, South Carolina, United States
SEA LEVEL RISE
LOCAL SCENARIOS
MAPPING CONFIDENCE
MARSH MIGRATION
VULNERABILITY
FLOOD FREQUENCY
WATER LEVEL
VIEW BY SCENARIO
VIEW BY YEAR
6ft
5ft
4ft
3ft
2ft
1ft
2100
2080
2060
2040
2020
2000
Extreme : 4.36ft
High : 3.67ft
Intermediate High : 2.76ft
Intermediate : 1.94ft
Intermediate Low : 1.21ft
CHARLESTON, SC
IN YEAR 2060
Cooper River
Ashley River
Drum Island
Hampton Park
The Citadel
Charles

“A state of denial can be a city’s worst enemy.”

- Mayor Michael Bloomberg, *Climate of Hope*

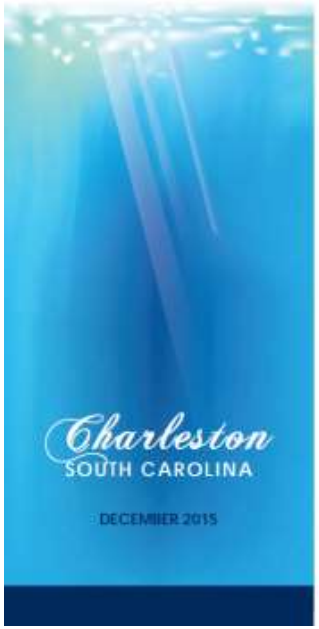


AWAKENING V
KING TIDE

- 9 public art works & 10 free events focused on rising tides & flooding streets in Charleston, SC
- Began Saturday, April 26 with People's Climate Parade and concluded Saturday, June 10, 2017
- Guided by Steering Committee of scientists, artists, non-profits, and organizations committed to addressing this issue



What are the projections?



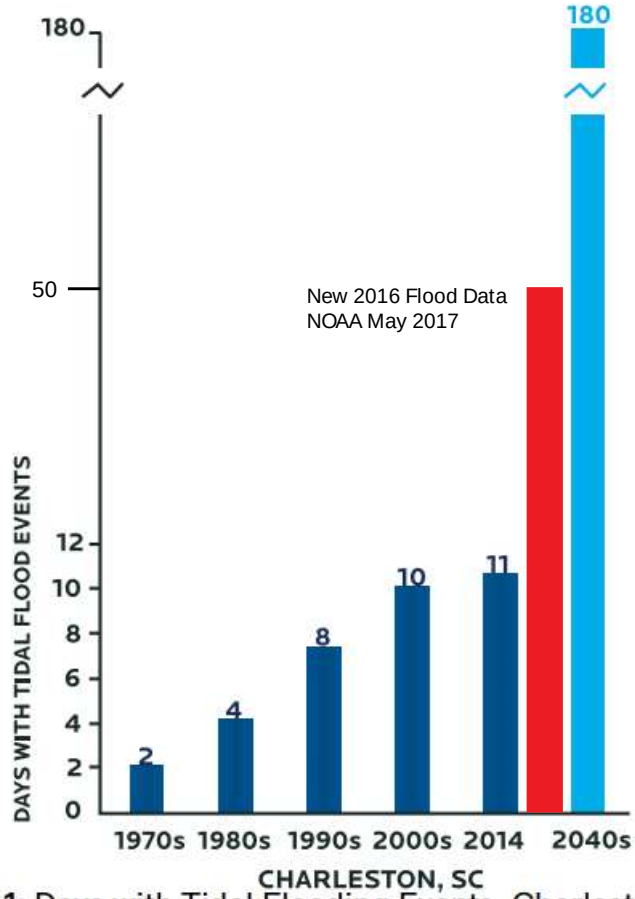


Figure 1: Days with Tidal Flooding Events, Charleston, SC

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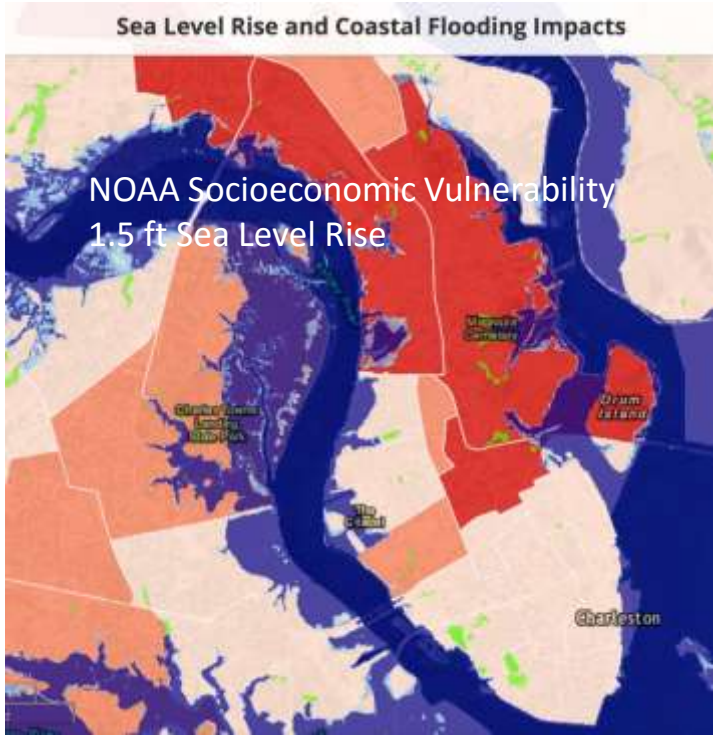
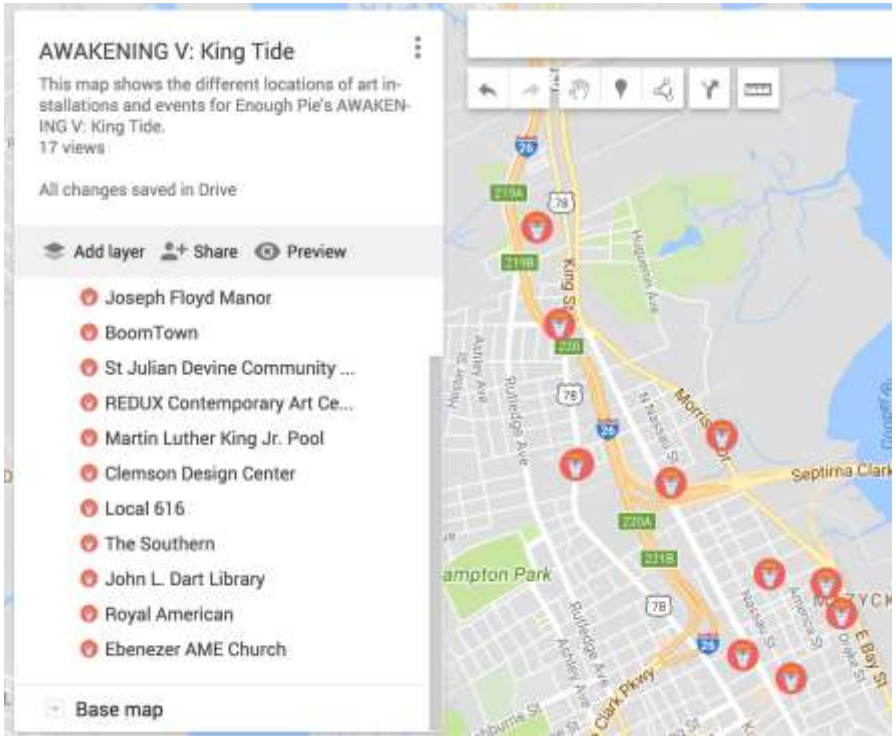
LOCATIONS





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Joseph Floyd Manor

Over 500,000+ viewership* of Mary Edna Fraser's 100-foot banner on the Joseph Floyd Manor stating 'WE ARGUE. NATURE ACTS.'

** per SCDOT traffic data*

Sanders-Clyde Elementary School

STORM WATER DRAIN MURAL

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Martin Luther King Jr. Pool (East Side)

UNDER THE SEA MURALS & PLEDGE

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WAVE OF HOPE

St. Julian Devine Community Center (East Side)

BY 2100: 2 FOOT WAVE

We have taken REAL action!

High tide will increase sea level rise by about 2 feet in 2100 if we take drastic measures to put tight restrictions on heat-trapping gases.

As individuals, we use less gas, eat local, plant more trees, use less heating and air-conditioning, use our renewable energy from the sun and wind and choose energy-efficient devices.

As a community, we honor climate treaties, advocate for alternative transportation, and support smart development, zoning, and storm water management that reduces flood risk.

BY 2100: 4 FOOT WAVE

We have taken SOME action.

This wave represents the impact of some melting glaciers plus the warming of our seas.

With moderate conservation, like burning less coal, driving more fuel-efficient cars, and generally consuming less, we might see 4 foot sea level rise. At this height, we have not taken the major steps necessary to reduce heat-trapping gases.

BY 2100: 7 FOOT WAVE

We have taken LITTLE action.

Whoa! This wave represents our lack of action as individuals and as a community.

Our lives and our consumption have not changed and thus the earth has warmed approximately 7 degrees by 2100. More and more heat-trapping gases have been released into the atmosphere causing the melting of land-based ice and the rising of the seas.

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20,000+ takeaways distributed

Illustrated by local artist Lisa Shimko

Personal, community and civic actions outlined

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Survey Collection

AWAKENING V KING TIDE

SHORT SURVEY

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HOW HAS FLOODING AFFECTED YOUR LIFE? (Circle all that apply)

A. Damaged your property or home
B. Made you late for an appointment or work
C. Limited your ability to walk, drive or bicycle in your community
D. Flooding has not affected me personally

HOW PREPARED IS YOUR HOUSEHOLD TO DEAL WITH A FLOOD?

1	2	3	4	5
Not Prepared		Moderately Prepared		Very Prepared

HOW HAVE YOU PREPARED?

_____

WHAT ACTIONS WILL YOU TAKE TO REDUCE YOUR FLOOD RISK? (Circle one)

A. Plant a rain garden
B. Adopt a storm drain in your community
C. Reduce impervious (concrete or asphalt) surfaces in your yard
D. Purchase flood insurance
E. Elevate or relocate your home
F. Share information about flooding with friends and family

HOW INFORMED WERE YOU ABOUT CHARLESTON FLOODS BEFORE THIS EVENT?

1	2	3	4	5
Not Prepared		Moderately Prepared		Very Prepared

WHAT DID YOU LEARN AT TODAY'S EVENT?

_____

MY STREET NAME & ZIP CODE: _____

THANK YOU FOR PARTICIPATING.
enoughpie.org

AWAKENING V SURVEY ZIP CODES

- 29403
- 29407
- 29401
- 29412
- 29464
- 29414
- 29455
- 29405
- 29466
- 29482
- 29485
- 29492

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Flood Affects

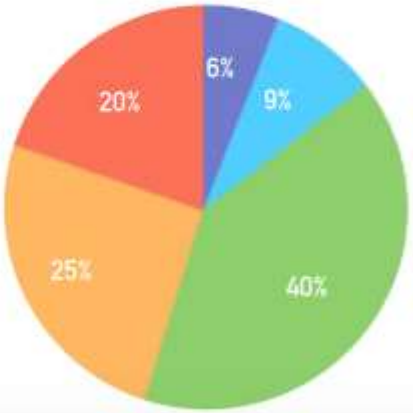
Question: How has flooding affected your life?

1. Limited my ability to walk, drive or bicyle in my community - 38%
2. Made me late for an appointment or work - 36%
3. Damaged my property or home - 20%
4. Flooding has not affected me personally - 6%

Informed vs. Prepared

How informed were you about Charleston floods before this event?

1. Not Informed - 6%
2. Somewhat Informed - 9%
3. Moderately Informed - 40%
4. Informed - 25%
5. Very Informed - 20%



How prepared is your household to deal with a flood?

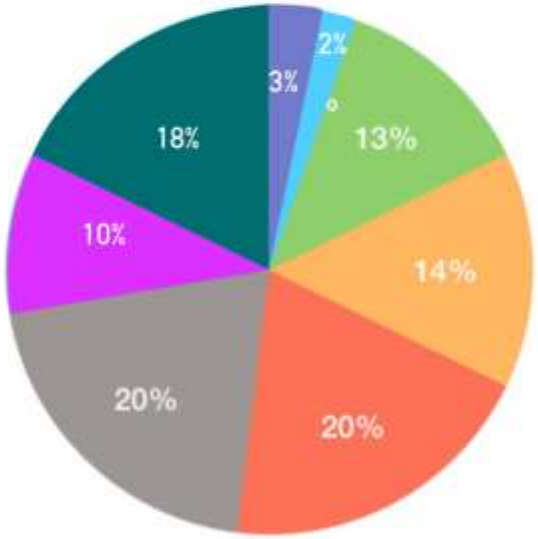
1. Not Prepared - 16%
2. Somewhat Prepared - 17%
3. Moderately Prepared - 48%
4. Prepared - 11%
5. Very Prepared - 8%

Flood Preparation

Question: How have you prepared?

Open ended questions were gathered and sorted into categories.

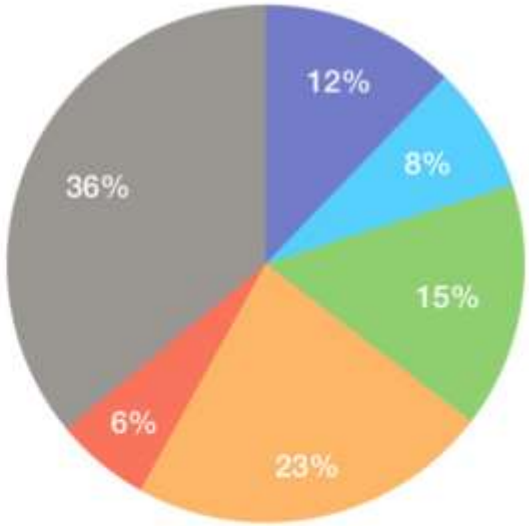
1. Live Above 1st Floor - 20%
2. Prepare Supplies - 20%
3. Retrofit Home - 18%
4. Insurance - 14%
5. Gather Information - 13%
6. Relocate - 10%
7. Clean Storm Drains - 3%
8. Environmental Conservation - 2%



Citizen Action

Question: What actions will you take to reduce your flood risk?

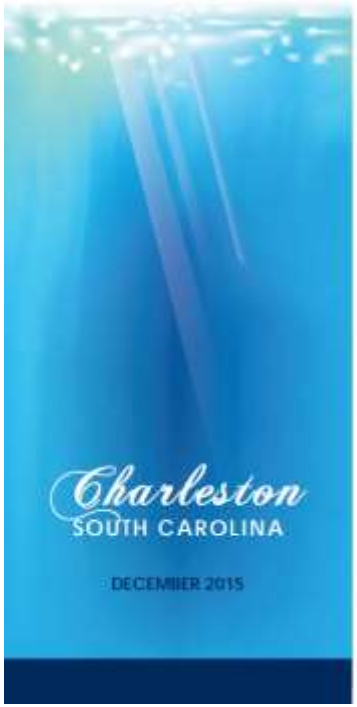
1. Share information about flooding with friends & family - 36%
2. Purchase flood insurance - 23%
3. Reduce impervious surfaces in my yard - 15%
4. Plant a rain garden - 12%
5. Adopt a storm drain in my community - 8%
6. Elevate or relocate my home - 6%



Recommendations

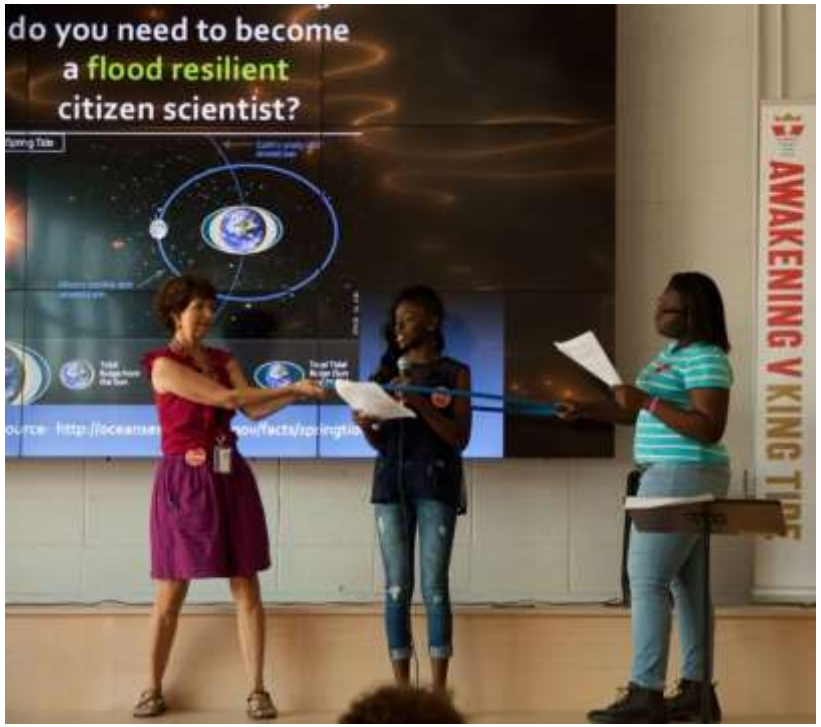
1. Support Sea Level Rise Strategy

2. Increase Capacity



Recommendations

3. Enhance outreach & education



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Recommendations

4. Improve infrastructure to accommodate water

5. Re-think development in flood-prone areas

Recommendations

6. Influence the future

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AWAKENING V
KING TIDE

STEERING COMMITTEE

Biohabitats and SC Audubon Society, Dr. Jessica Hardesty Norris
Charleston Resilience Network
CharlestonGOOD, Jacara Chas
Charleston Moves, Katie Zimmerman
Charleston Waterkeeper, Andrew Wunderly
City of Charleston Planning Department, Carolee Williams
Coastal Conservation League, Emily Cedzo
CULTIVATE and **College of Charleston Grice Marine Lab**, Dr. Bobbie Lyon
Davis & Floyd, Jared Bramblett
Enough Pie, Cathryn Zommer, Bennett Jones and Kate Nevin
Historic Charleston Foundation, Erika Hoffman
NOAA, Dr. Mary Culver
Robinson Design Engineers, Joshua Robinson
SC Department of Environmental Control, Dan Burger
SC Sea Grant Consortium, Dr. Liz Fly
University of SC Center for Science Education, Dr. Merrie Koester
South Carolina Aquarium, Albert George & Kelly Thorvalson
Artists Mary Edna Fraser, Kris Westerson, Cecelia Dailey, and John Duckworth

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AWAKENING V
KING TIDE

IT WILL TAKE A VILLAGE.

ACTION **NOW** IS A BARGAIN COMPARED TO WHAT IT WILL COST LATER.

CITY OF CHARLESTON RESILIENCE WORKGROUP

PROCESS

- Start with Sea Level Rise Strategy
- Jan – June (6 months – 10 meetings)
- Process 76 Initiatives
  - Work through each one/validate/ongoing/$
  - Goal was 2018 budget inputs – made it!

CITY OF CHARLESTON RESILIENCE WORKGROUP

WHAT DID WE LEARN?

- Resilience is a continuum (individual, neighborhood, city)
- Lots already going on to build Resilience
- Lots outside our control i.e. roads & bridges!
- Need solutions – *integrated response* verses *independent actions*.
- Regional solutions will be essential!
- Starts with the City of Charleston.

CITY OF CHARLESTON RESILIENCE WORKGROUP

RESULTS

- Make Charleston Resilient for the Future – Plan and Adapt (60 years + start today)
- Four Major Categories
  - Staff Leadership – (Ready)
  - Infrastructure & Regulations – (Reinvest)
  - Land Use Planning – (Ready)
  - Adapting for the Day to Day (Respond)

CITY OF CHARLESTON RESILIENCE WORKGROUP

RECOMMENDATIONS

- Chief Resilience Officer – Resilience Leadership
- Vulnerability Assessment – First to a solution
- Invest in adaptation
  - Personnel & resources
  - New & expanding technology
  - Creative and adaptive community
    - Whole community
    - Flexible and scalable

USING DATA TO DRIVE DECISION-MAKING

Using data to identify areas with the greatest potential impact from Sea Level Rise

- Sea Level Rise Prediction Model data
- FEMA Preliminary Flood Insurance Rate Maps (FIRMs)
- Recent Road Closure data
- Critical Infrastructure & Historical Assets Exposure
- Traffic Counts

Too important and costly to leave to intuition or the "squeaky wheel"

1	**Road Closure (Flooding) Density based on Proximity and Frequency**
2	Sea Level Rise
3	Sea Level Rise and Road Closure Density
4	SCDOT Annual Daily Traffic Counts 2015
5	Social Vulnerability
6	Critical Facilities
7	Peninsula Storm Water Projects
8	100 Year Flood Zone Exposure Analysis
9	Current Development Projects

1	Road Closure (Flooding) Density based on Proximity and Frequency
2	**Sea Level Rise (2.5' NOAA Predicted)**
3	Sea Level Rise and Road Closure Density
4	SCDOT Annual Daily Traffic Counts 2015
5	Social Vulnerability
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7	Peninsula Storm Water Projects
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1	Road Closure (Flooding) Density based on Proximity and Frequency
2	**Sea Level Rise (2.5' NOAA Predicted & Original High Water Mark)**
3	Sea Level Rise and Road Closure Density
4	SCDOT Annual Daily Traffic Counts 2015
5	Social Vulnerability
6	Critical Facilities
7	Peninsula Storm Water Projects
8	100 Year Flood Zone Exposure Analysis
9	Current Development Projects

1	Road Closure (Flooding) Density based on Proximity and Frequency
2	**Sea Level Rise (3.0' NOAA Predicted & Original High Water Mark)**
3	Sea Level Rise and Road Closure Density
4	SCDOT Annual Daily Traffic Counts 2015
5	Social Vulnerability
6	Critical Facilities
7	Peninsula Storm Water Projects
8	100 Year Flood Zone Exposure Analysis
9	Current Development Projects

1	Road Closure (Flooding) Density based on Proximity and Frequency
2	Sea Level Rise
3	**Sea Level Rise (2.5') and Road Closure Density**
4	SCDOT Annual Daily Traffic Counts 2015
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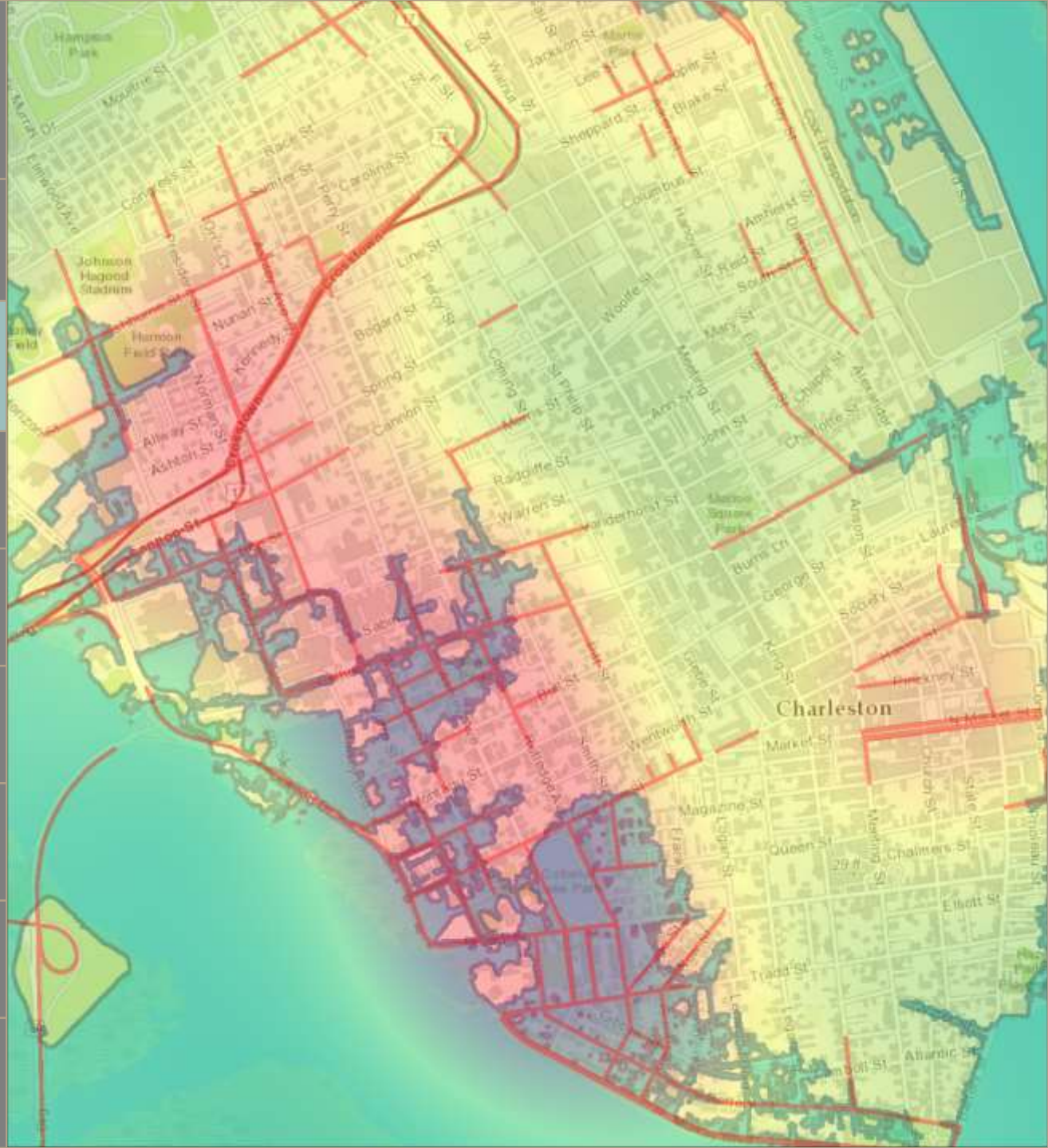
8	100 Year Flood Zone Exposure Analysis
9	Current Development Projects



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3	**Sea Level Rise (3.0') and Road Closure Density**
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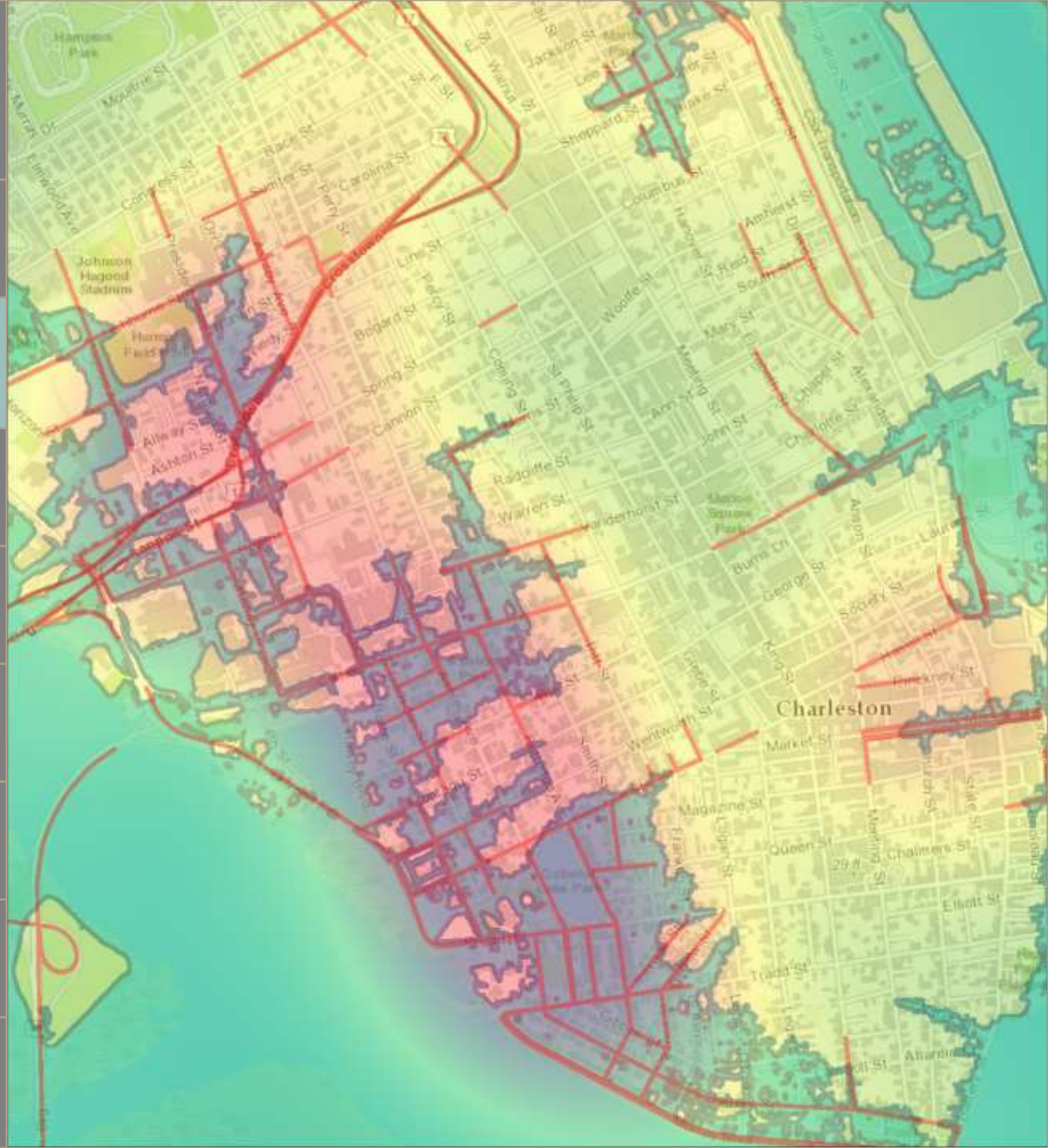

1	Road Closure (Flooding) Density based on Proximity and Frequency
2	Sea Level Rise
3	Sea Level Rise (3.0') and Road Closure Density
4	**SCDOT Annual Daily Traffic Counts 2015 (& 3.0' SLR)**
5	Social Vulnerability
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1. Road Closure (Flooding) Density based on Proximity and Frequency
2. Sea Level Rise
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4. SCDOT Annual Daily Traffic Counts 2015 (& 3.0' SLR)
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6. **Critical Facilities**
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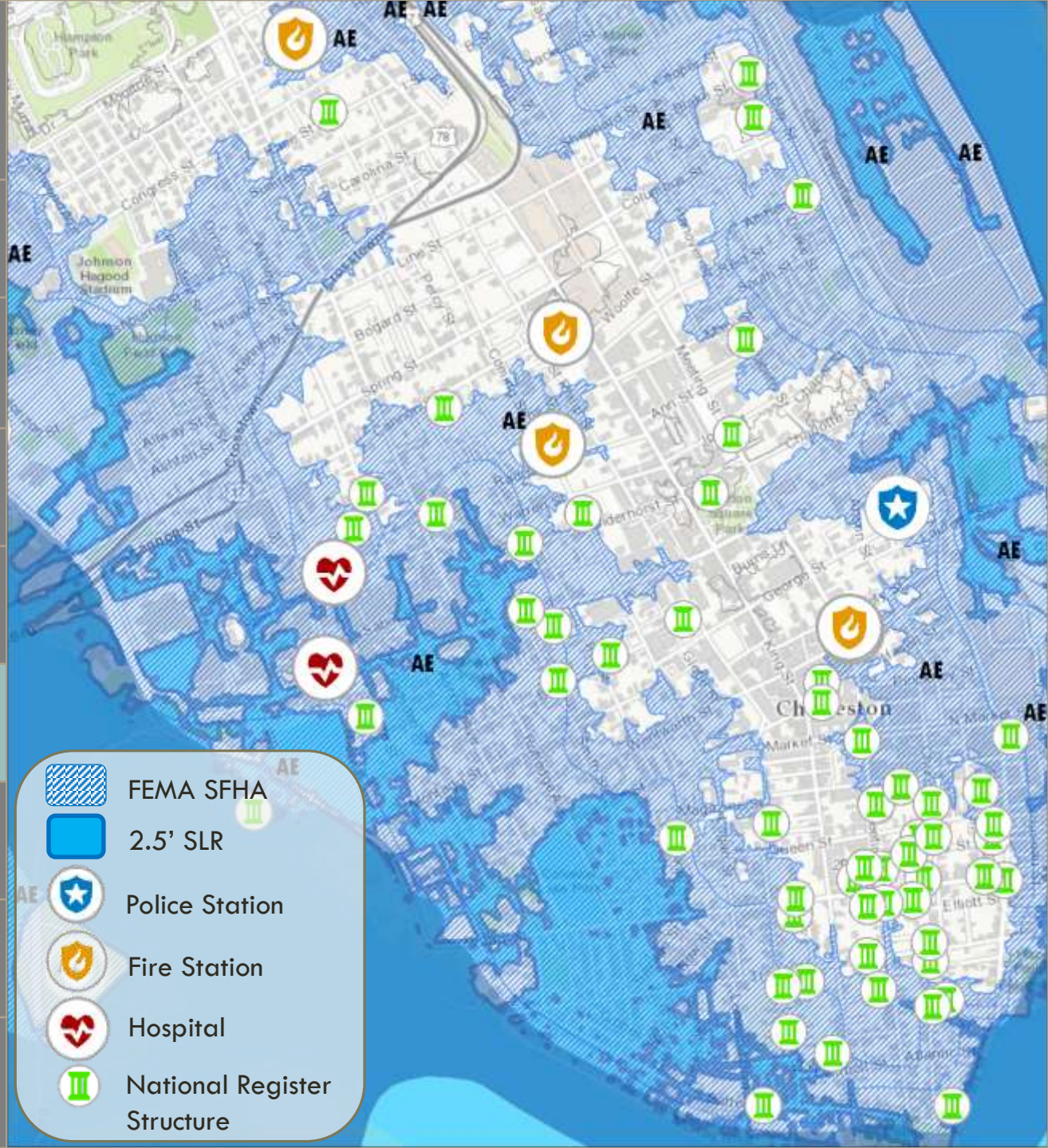

1. Road Closure (Flooding) Density based on Proximity and Frequency
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3. Sea Level Rise (3.0') and Road Closure Density
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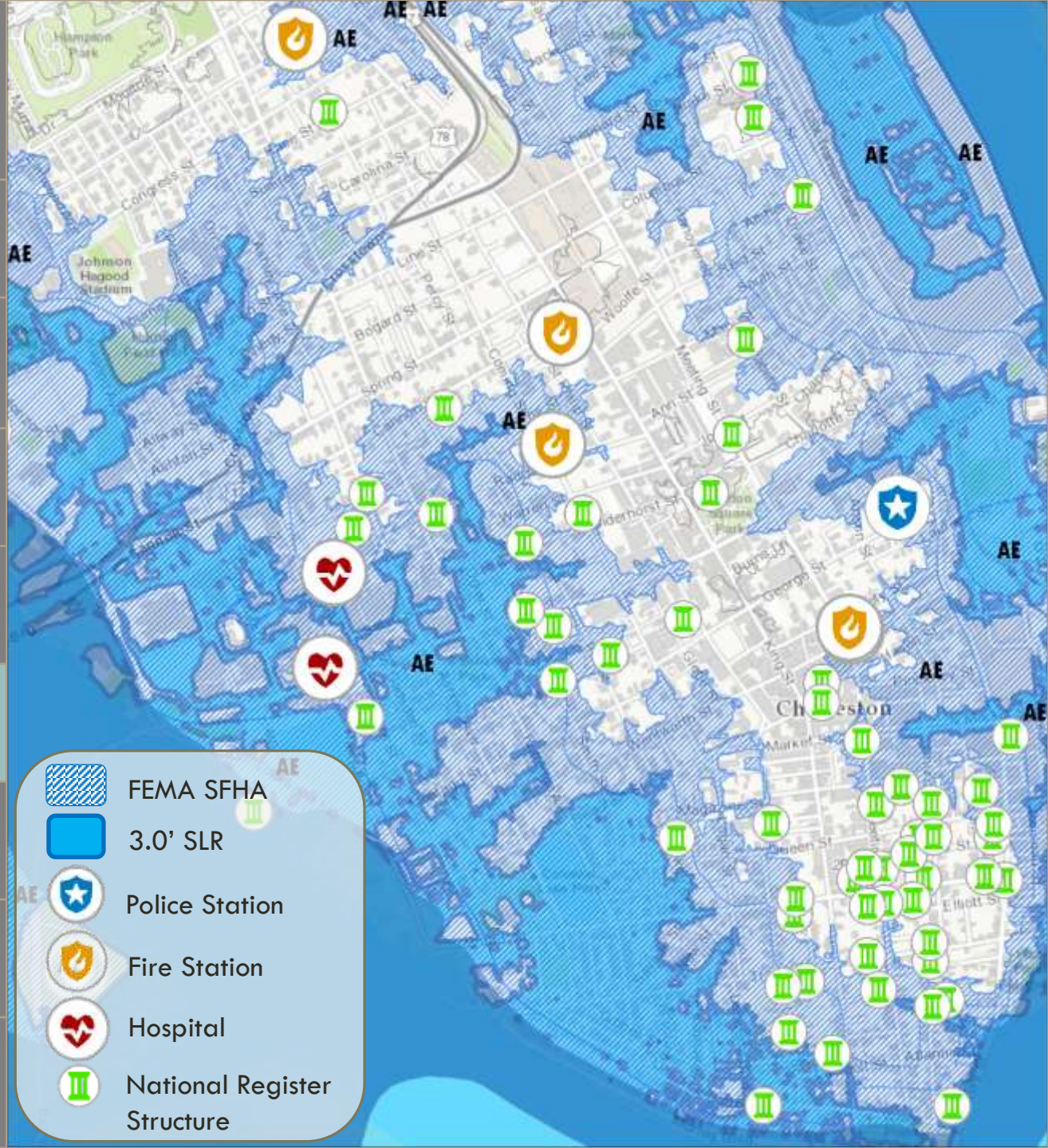
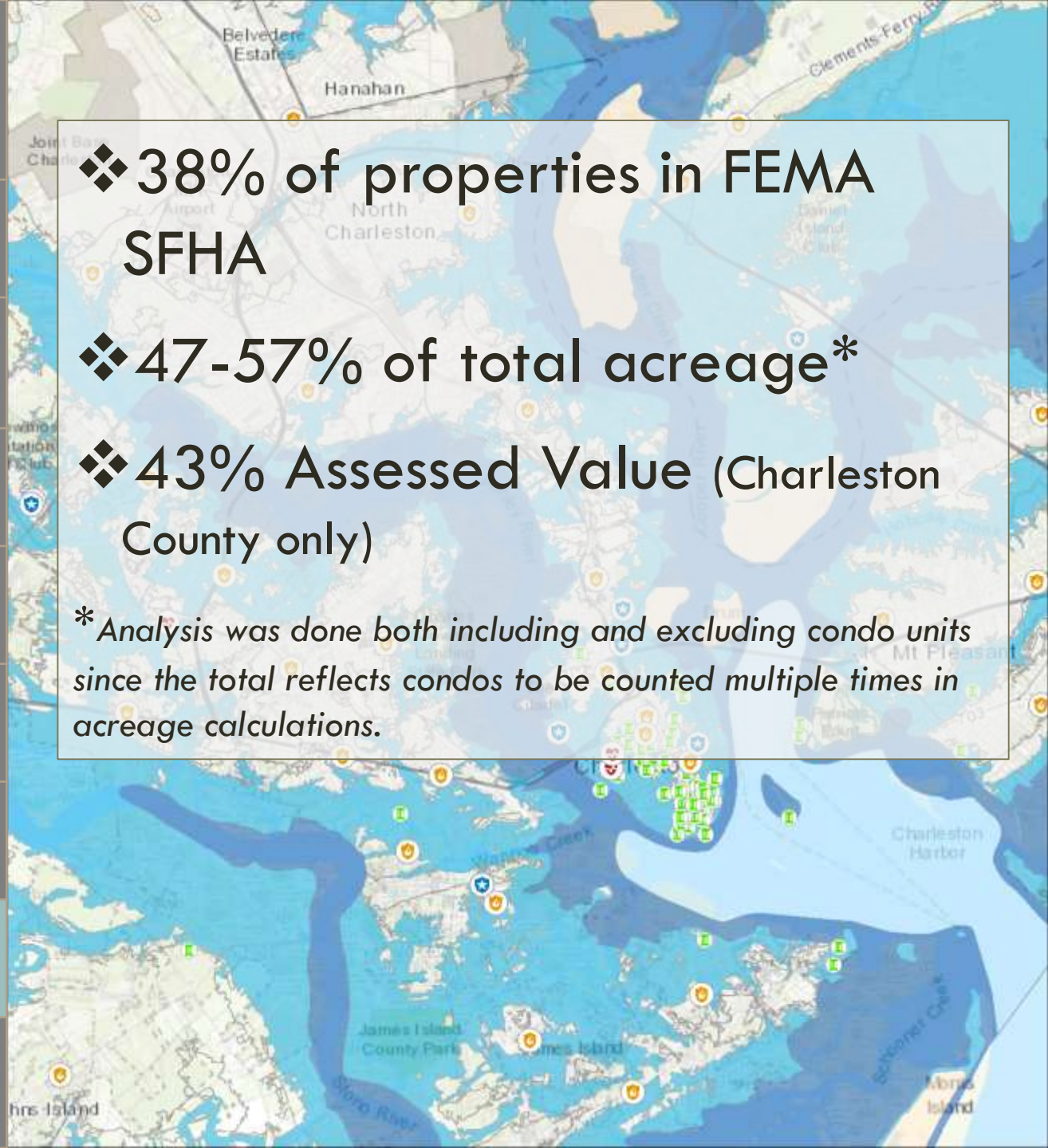
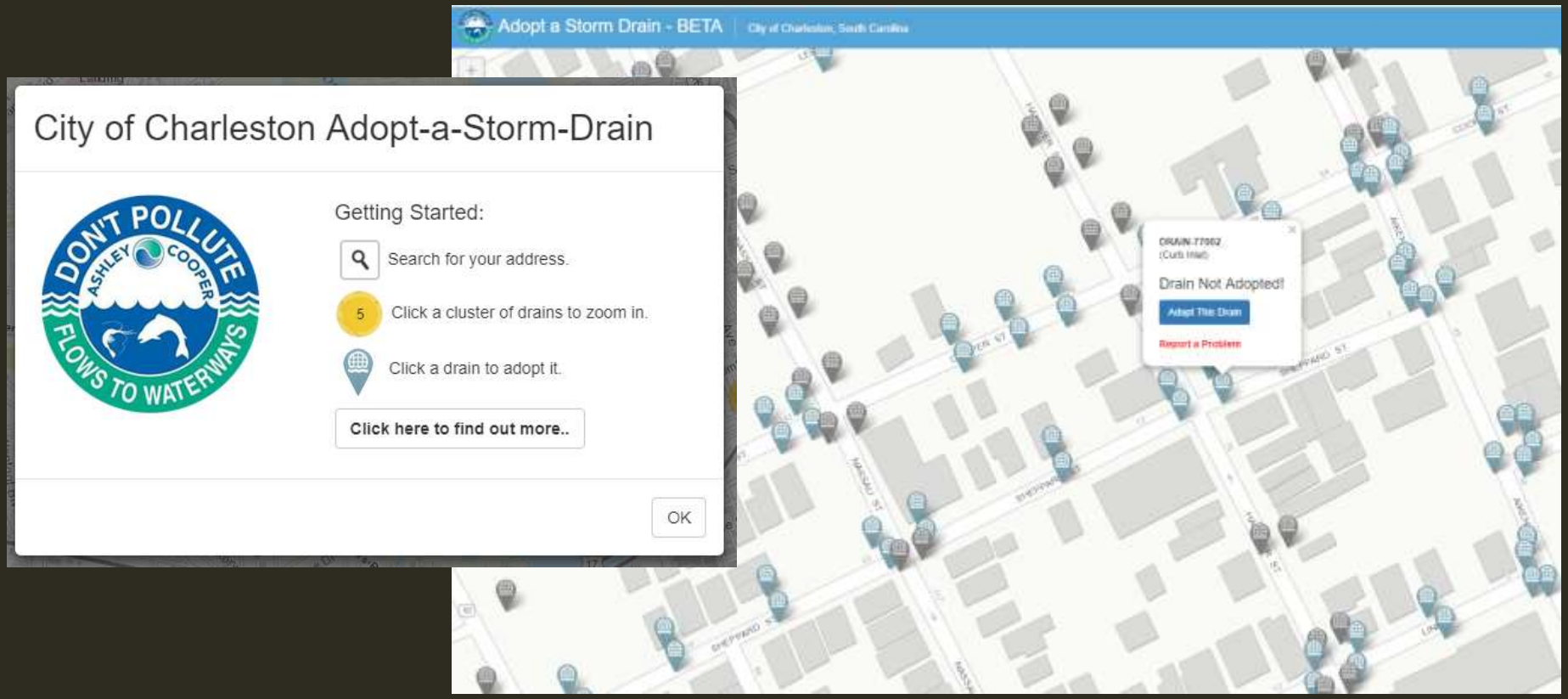




- 38% of properties in FEMA SFHA
- 47-57% of total acreage*
- 43% Assessed Value (Charleston County only)

**Analysis was done both including and excluding condo units since the total reflects condos to be counted multiple times in acreage calculations.*

ADOPT-A-DRAIN PROGRAM



NEXT STEPS

- Community input to better understand the needs and concerns of our citizens

- Vulnerability Analysis

CITY OF CHARLESTON RESILIENCE VULNERABILITY ANALYSIS

VULNERABILITY ANALYSIS – OURS TO SHAPE.

- Threats and Hazards
  - Flooding, hurricanes, earthquakes, sea level rise, heat etc.
- City wide Assets
  - City owned facilities, commercial and residential property, bridges, roads, critical infrastructure etc.
- Vulnerability = (Potential Impact to Assets from Threats- Adaptive Capacity)
- Risks = probability and consequence (high to low)

CITY OF CHARLESTON RESILIENCE

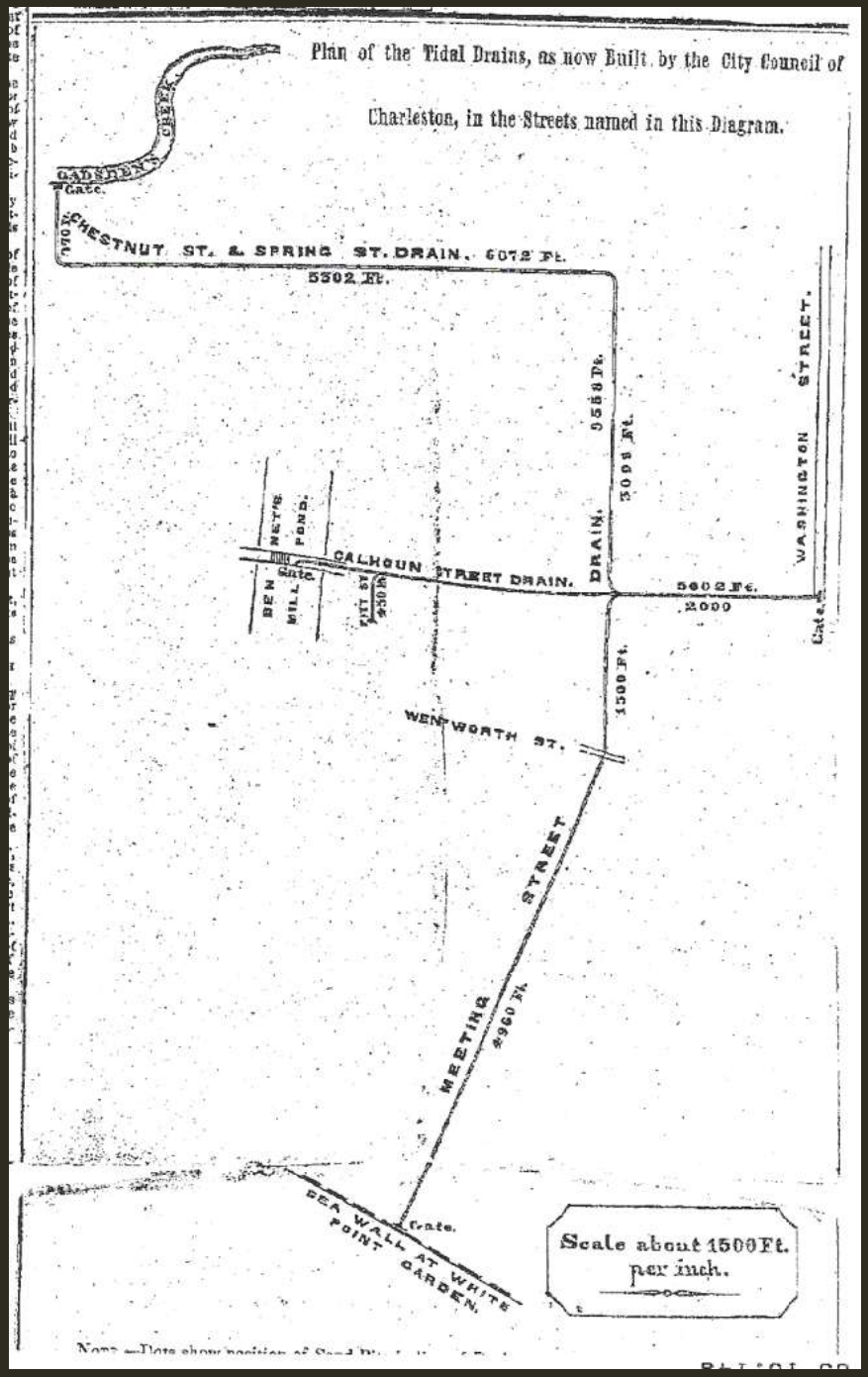
"You must have a solution – not just a collection of widgets"

CHARLESTON GEOGRAPHY

Original High Tide Water Lines

Charleston Today

JUNE 1,1859 PLAN OF NEW TIDAL DRAINS AS NOW BUILT BY THE CITY COUNCIL OF CHARLESTON



1878 MAP OF TIDAL DRAINS

Interconnected network of undersized pipes and drains

RAINFALL FLOODING

CITY MARKET RAINFALL FLOODING

OCTOBER 2015 FLOOD EVENT

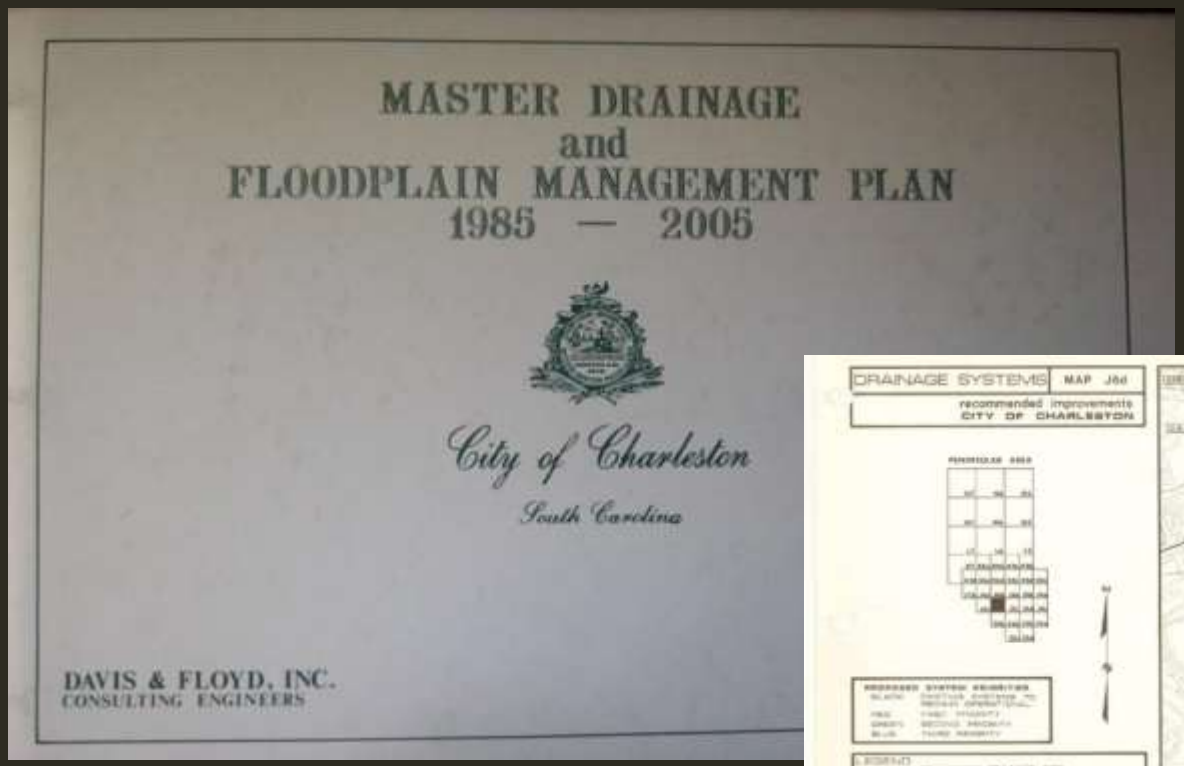
TIDAL FLOODING

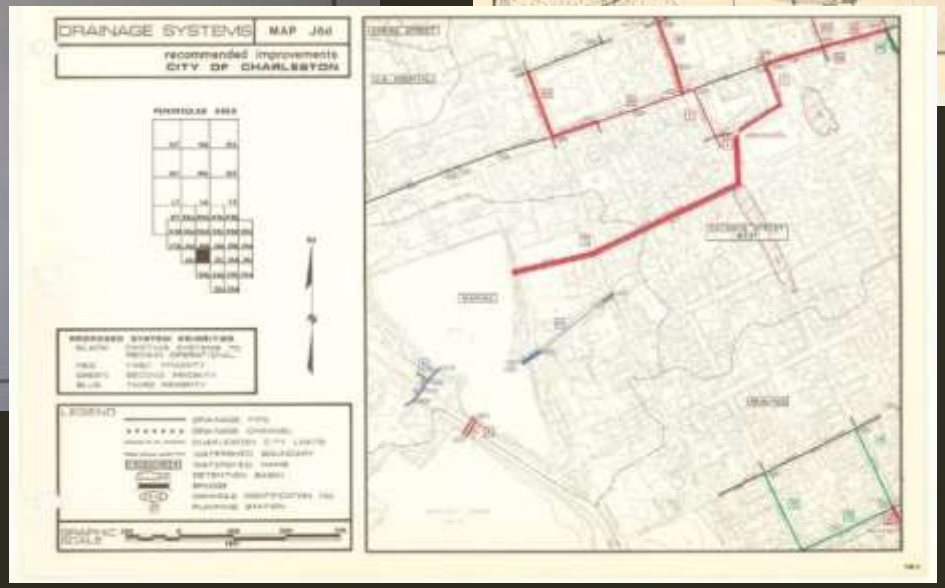

City Marina Lockwood Boulevard
September 29, 2015


Morrison Drive

HURRICANE MATTHEW
OCTOBER 2016

1984 MASTER DRAINAGE AND FLOODPLAIN MANAGEMENT PLAN

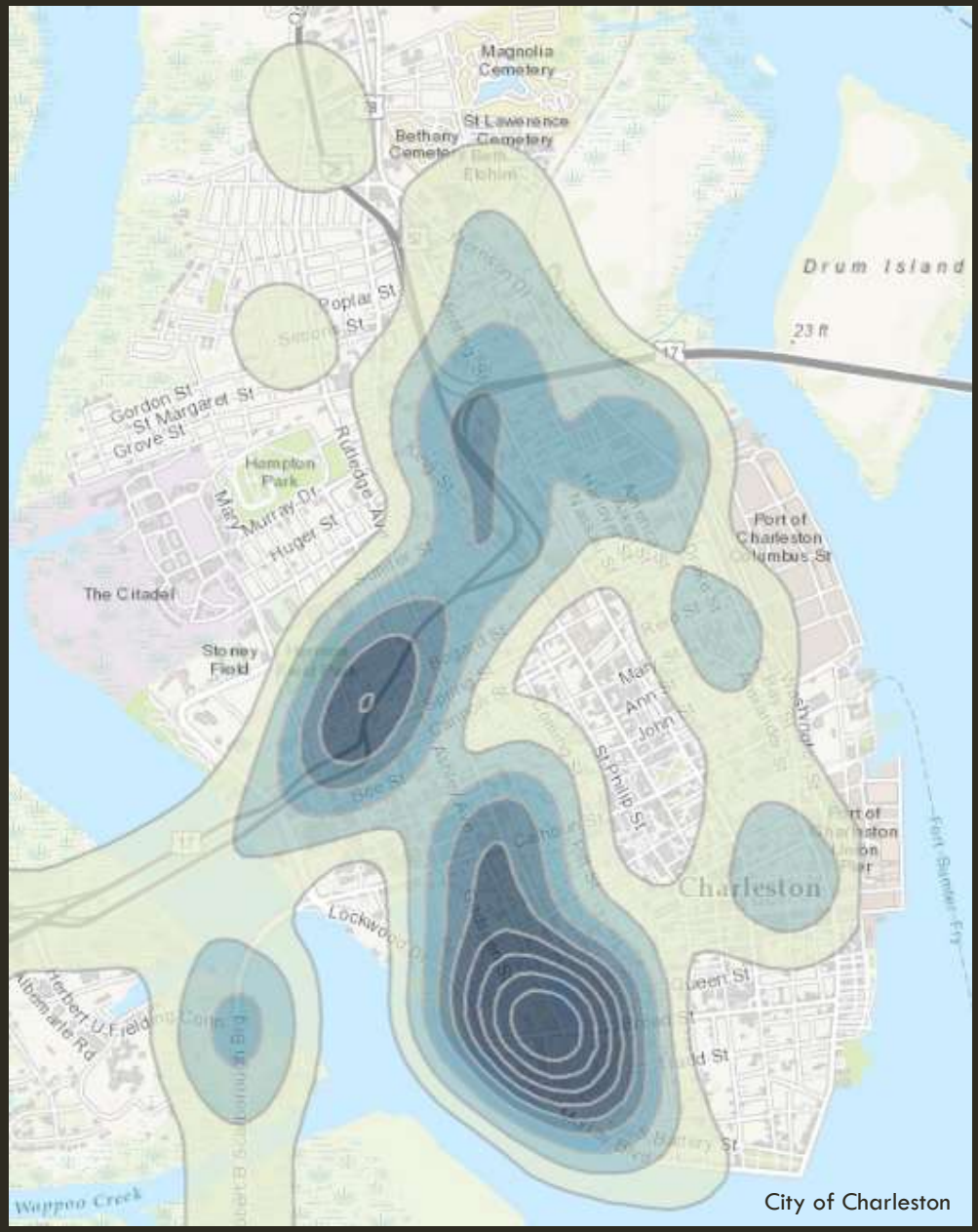




MAJOR DRAINAGE IMPROVEMENT PROJECTS

ROAD CLOSURES DURING OCTOBER 2015 RAINFALL EVENT

We are working our plan



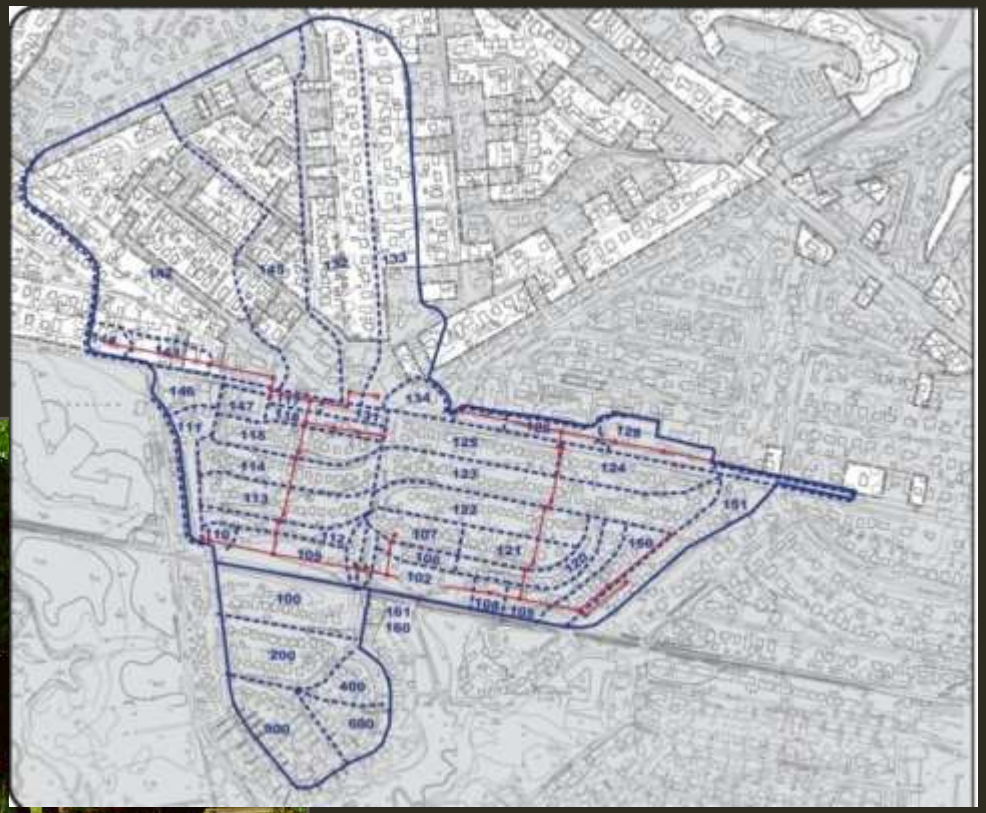
GRAVITY, CAPACITY AND STORAGE

Ardmore Drainage Improvements Completed 2005

- 11 acres of detention ponds
- 5x9.5 and dual 5x8 box culverts
- $5,048,000

GRAVITY, CAPACITY AND STORAGE

Byrnes Down
Completed 2007
$6,683,561



- 10,000 lf of box culvert and pipes
- Largest box culverts were 4x7 and 5x6 ft.

GRAVITY, CAPACITY AND STORAGE

TUNNEL COLLECTION AND PUMPING

TUNNEL COLLECTION AND PUMPING

Calhoun East (Calhoun, East Bay and Meeting Streets)

Complete 2001, 5,000 ft of 10 ft and 6 ft diameter tunnels

Cost approximately **$16,000,000**

TUNNEL COLLECTION AND PUMPING

Market Drainage Improvement

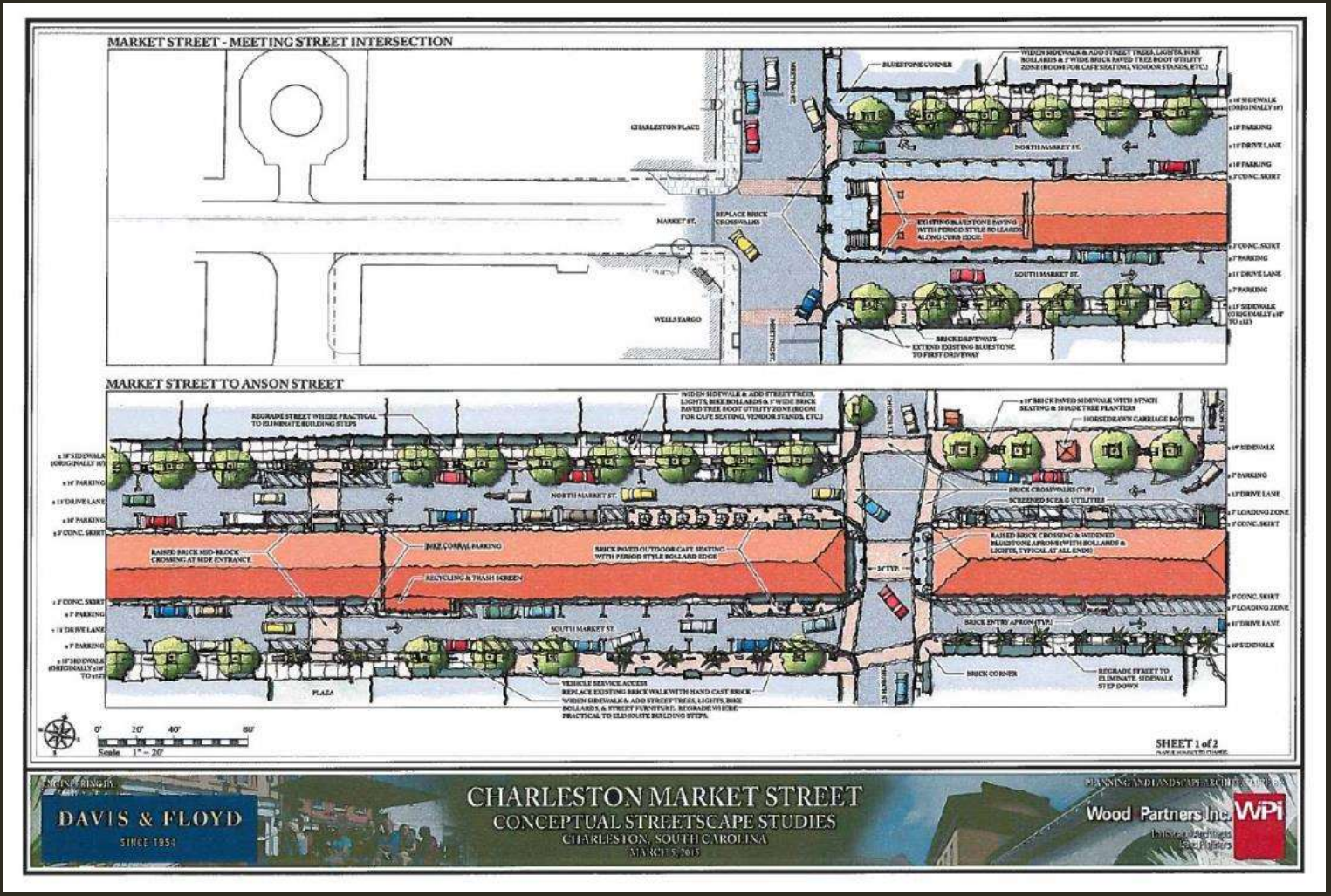
2 phases of construction complete for $18.5 million

4,000 ft 10 ft diameter tunnels

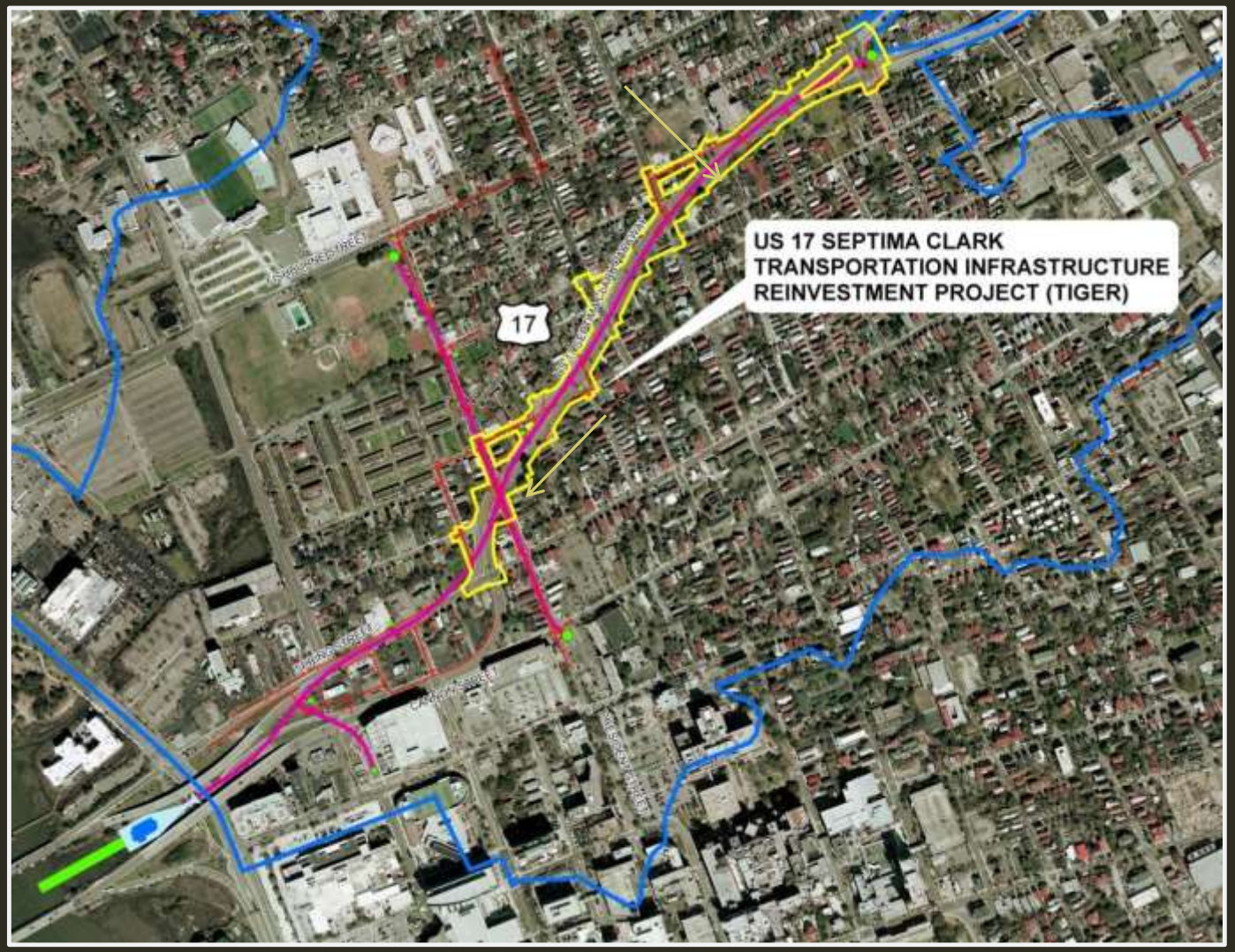
Division III Surface work to commence in 2018

Estimated cost to complete is $8 million

TUNNEL COLLECTION AND PUMPING



TUNNEL COLLECTION AND PUMPING



SPRING FISHBURNE LOCKWOOD SHAFT

SPRING FISHBURNE TBM

SPRING FISHBURNE DROP SHAFT

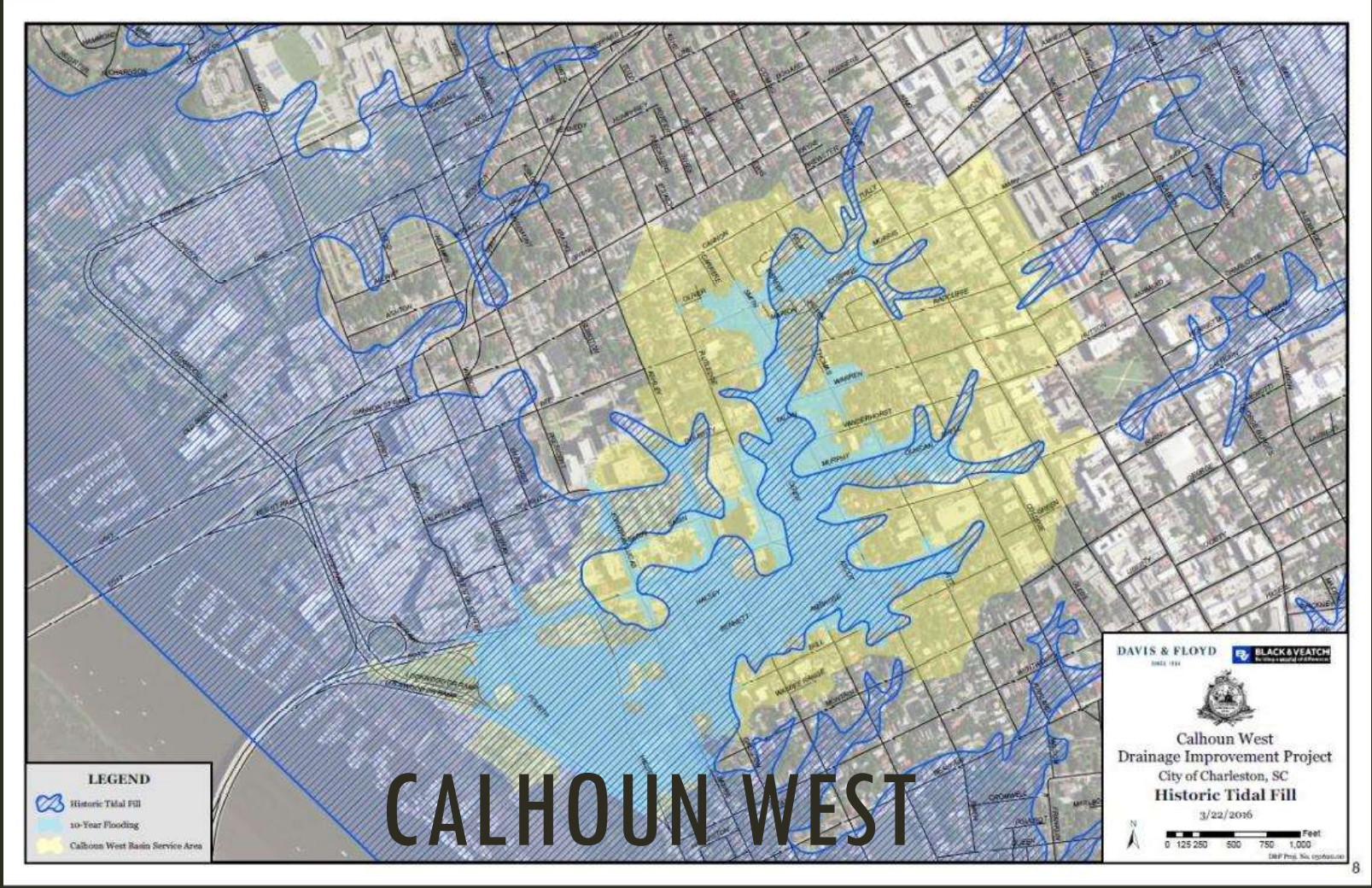
SPRING/FISHBURNE VORTEX BOX

SPRING/FISHBURNE VORTEX BOX

TUNNEL COLLECTION AND PUMPING

US17 SPRING/FISHBURNE DRAINAGE IMPROVEMENT PROJECT

TUNNEL COLLECTION AND PUMPING



CALHOUN WEST

RAISING ROADS, ARMORING AND WALLS

Oct 3, 2015 11 inches of rain and highest tides since Hugo

RAISING ROADS, ARMORING AND WALLS

BATTLEGROUND ROAD ARMORING

REGULATIONS

- Individual watershed analysis
- Updated development standards
- Green infrastructure
- Buyouts and elevation projects
- Adopt a drain
- Increased awareness of flood risk
- Hiring a dedicated floodplain manager

FUNDING

- 2 mil assessment dedicated to drainage (1990)
- Leveraged $9M bond in 1990
- FEMA Mitigation Grant – Hugo $2.3 million
- SCDOT Funding $1.5M for Calhoun/East Bay
- Stormwater Utility established 1994 ($6.00 per ERU or about $6.5 million per year)

Ardmore $5,000,000
Calhoun East $16,000,000
Byrnes Down $6,000,000
Spring/Fishburne $154,000,000
Market Street $30,000,000

FUNDING

- $110.5M grants and contributions awarded
  - $10M ARRA TIGER Grant
  - $12.5 50/50 Match from SCDOT/FHA
  - $88M SIB
- Balance from the Gateway TIF
- Additional 2 mil dedicated to drainage beginning in 2016 ($2.2 million per year)
- Possible USACOE funding

$238,000,000 CAPITAL INVESTMENT BETWEEN 1990 AND 2020

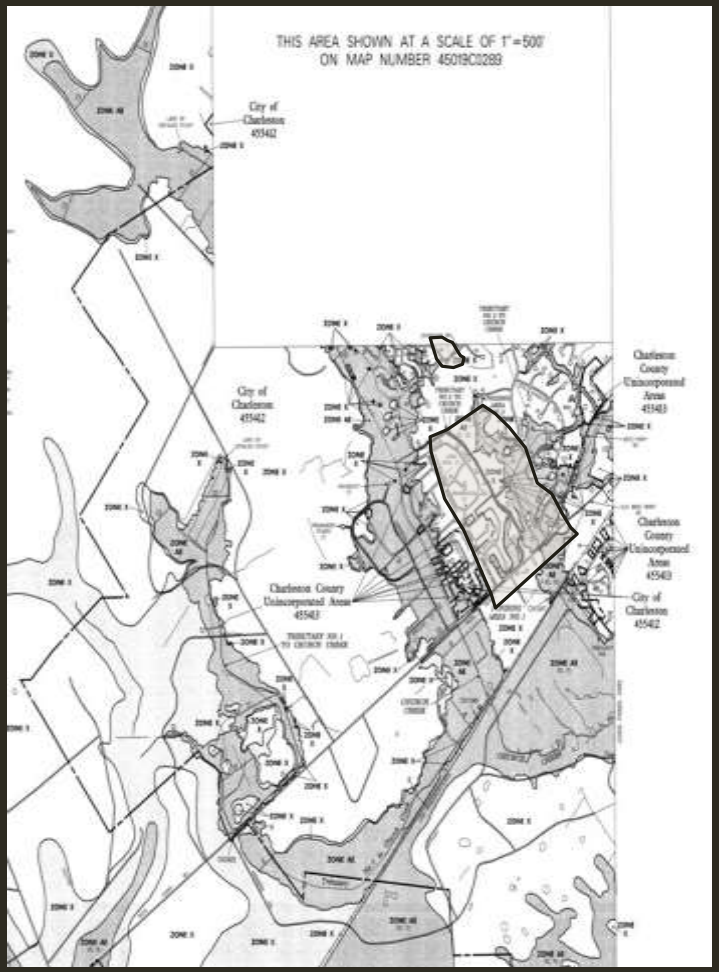
- $107M Complete
- $50M Under contract for design and construction
- $Additional $81M Funded

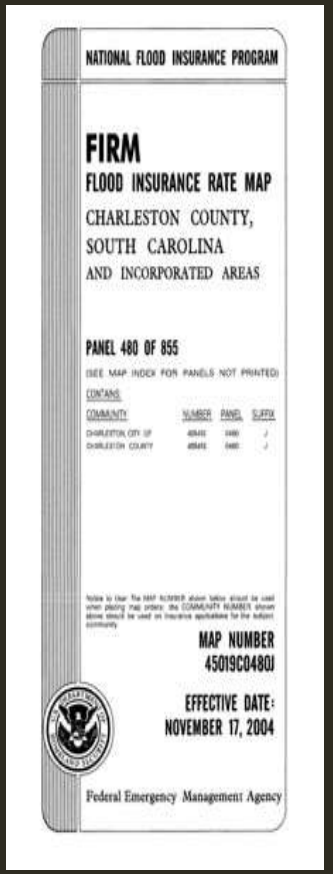
- $4.1 2016 Maintenance Budget

FINAL COMMENTS

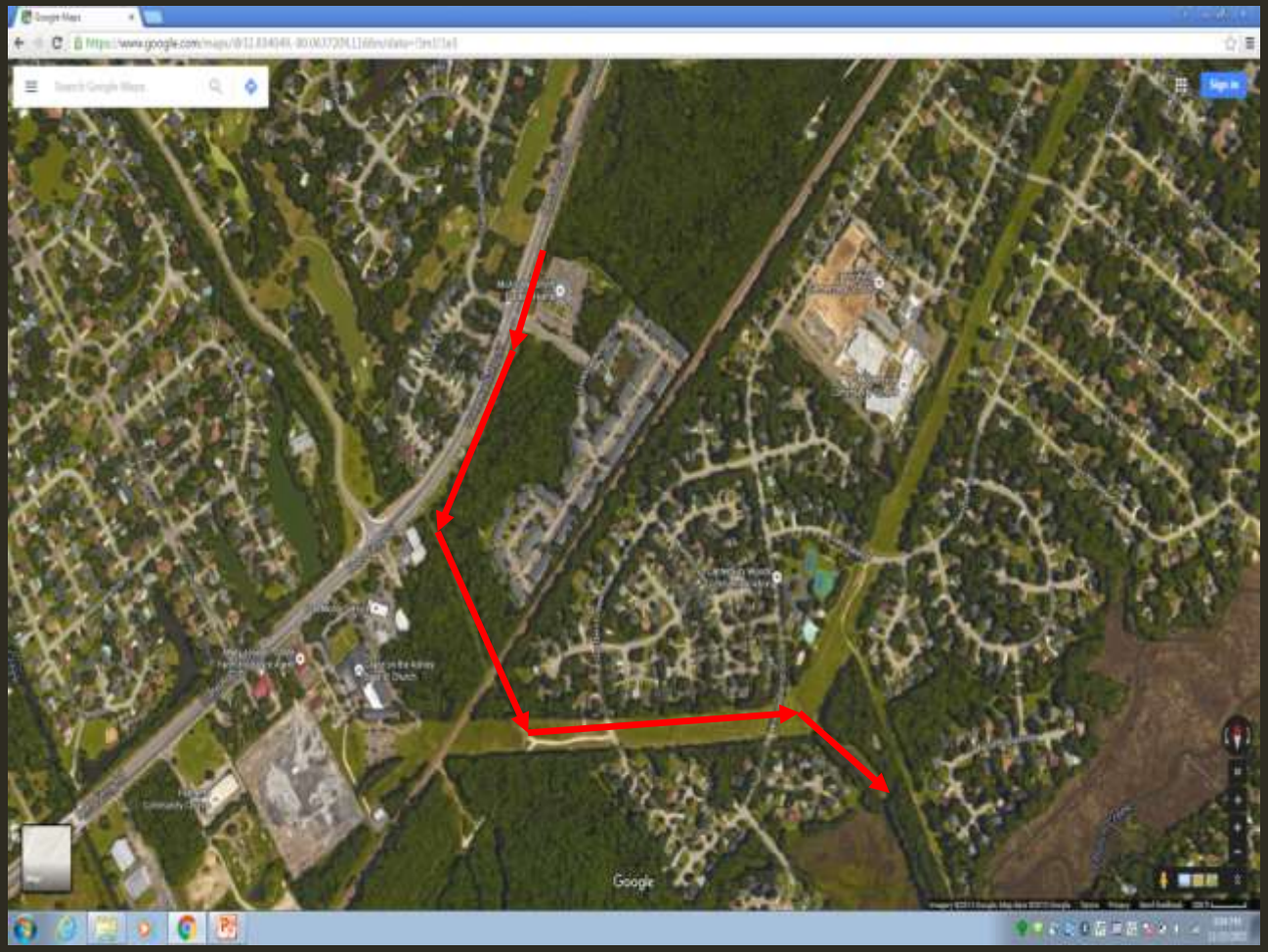
- Some areas won't be improved by engineering
- Project would adversely affect more than it would help or cost more than the properties it would effect
- Maintenance would be excessive
- Other opportunities for buyouts, elevation and risk awareness

FEMA MAP REVISION 2004





DIVERSION ROUTE



WOOLPERT

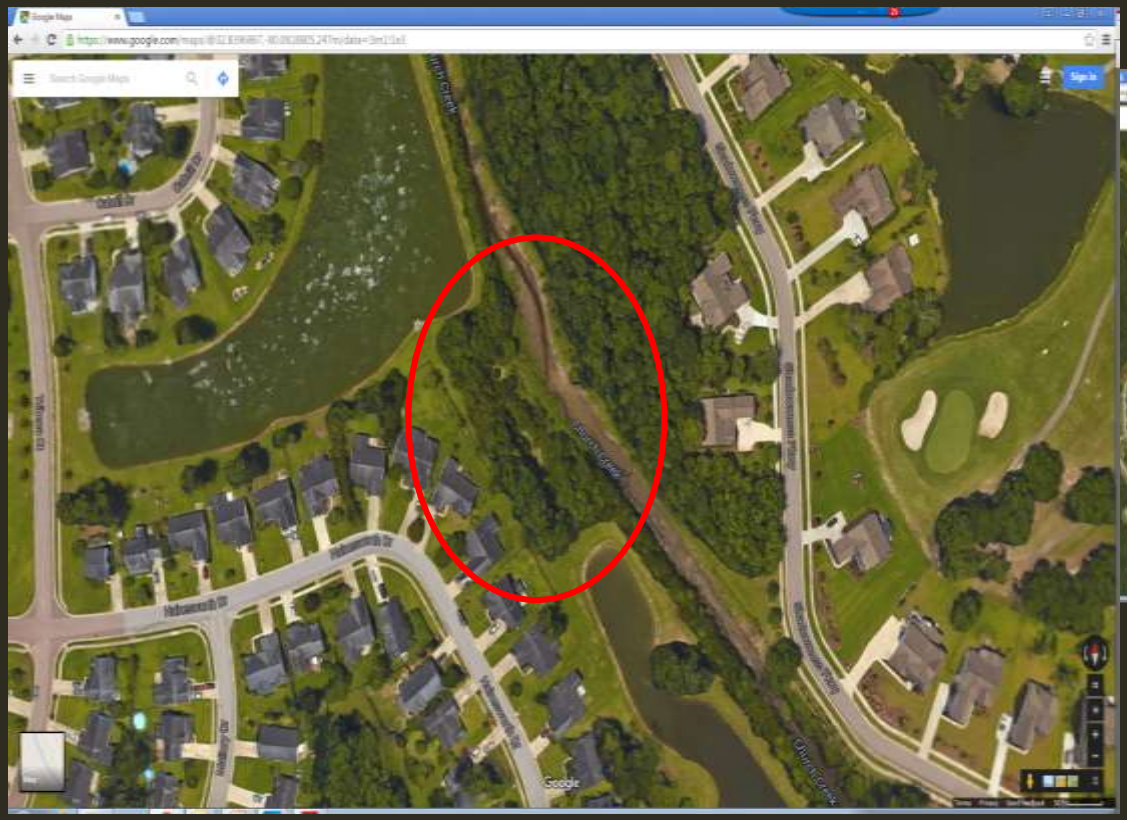
ALTERNATIVE 2C

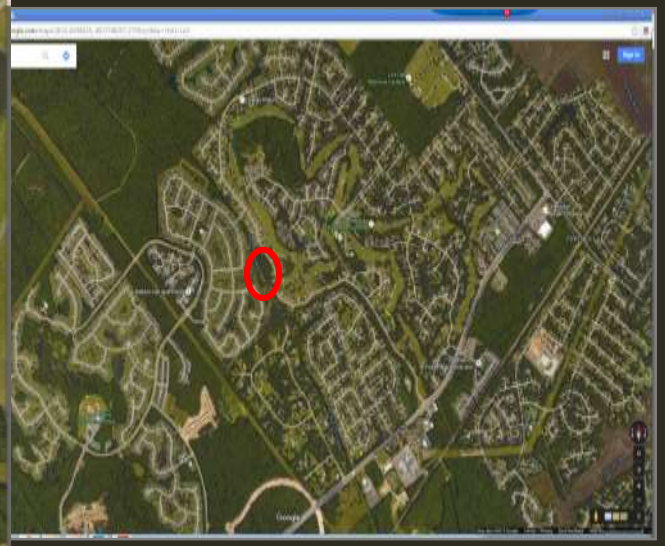
- 1700’ of 8’ x 4’ box culvert
- Bore and Jack box culvert under CSX railroad
- Multiple County road crossings
- New drainage infrastructure in SCDOT and SCE&G ROW
- Twin 48” RCP culvert abandonment
- 10’ x 3’ box culvert under drainage ditch
- 5600’ of diversion channel
- >1 acre of wetlands conversion
- Upgraded spillway and outfall through old sludge lagoon

ALTERNATIVE 2C

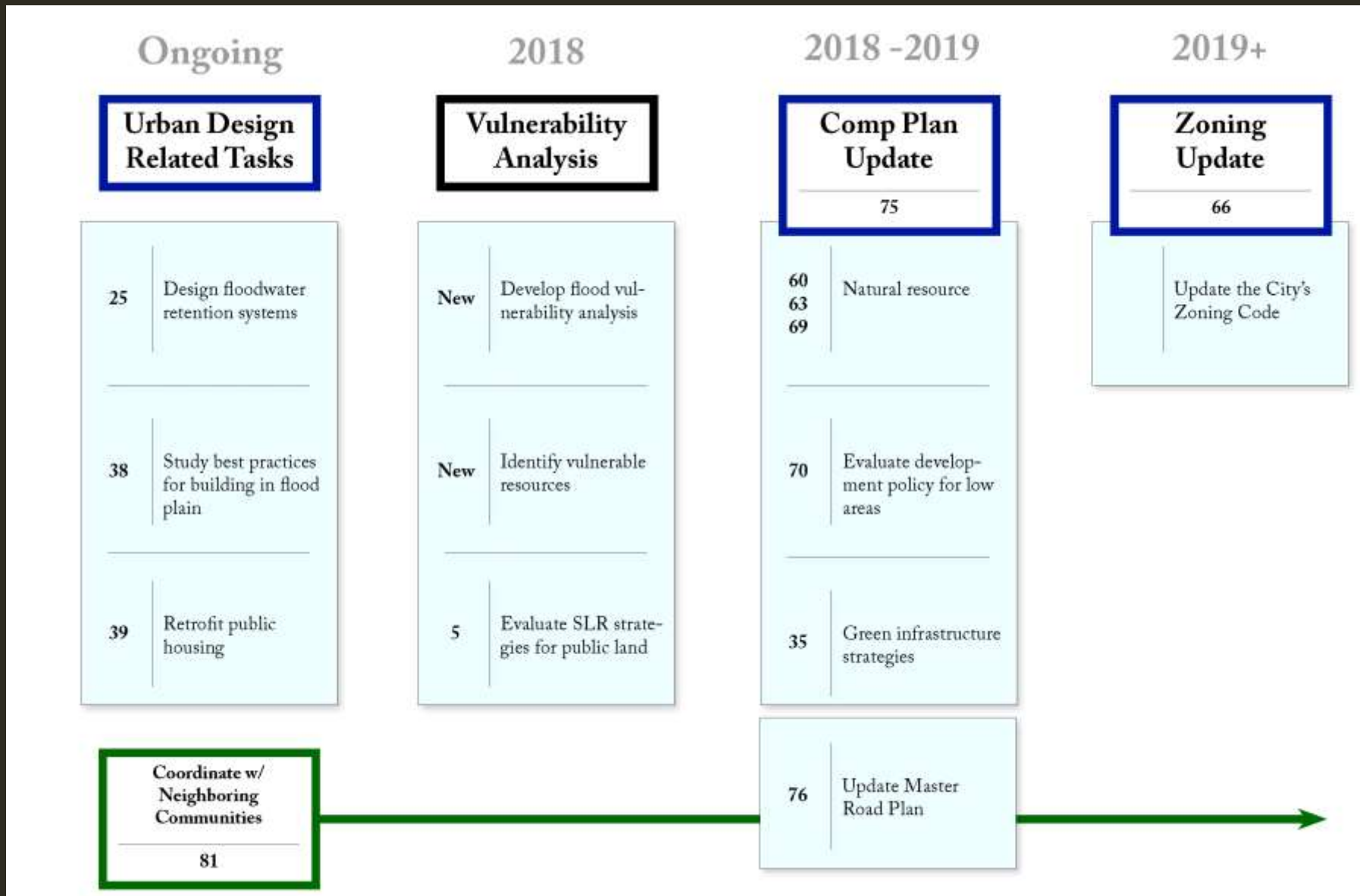
ALTERNATIVE 5

Overflow flood storage from main stem





BRIDGEPOINT RELIEF CULVERT


Ongoing
2018
2018 -2019
2019+
Urban Design Related Tasks
25
Design floodwater retention systems
38
Study best practices for building in flood plain
39
Retrofit public housing
Vulnerability Analysis
New
Develop flood vulnerability analysis
New
Identify vulnerable resources
5
Evaluate SLR strategies for public land
Comp Plan Update
75
60
63
69
Natural resource
70
Evaluate development policy for low areas
35
Green infrastructure strategies
Zoning Update
66
Update the City's Zoning Code
Coordinate w/ Neighboring Communities
81
76
Update Master Road Plan

CITY OF CHARLESTON RESILIENCE LIVING WITH WATER - ADAPTING

- Increased flooding = increased strain
- Police, Public Service, Fire, GIS, PIO
  - Police
    - Overtime
    - Barricades
  - Fire
    - Unique equipment
    - Specialized training
  - Public Service
    - Drain cleaning and clearing
  - Community Outreach and Messaging
    - New technologies
    - GIS, PIO etc.